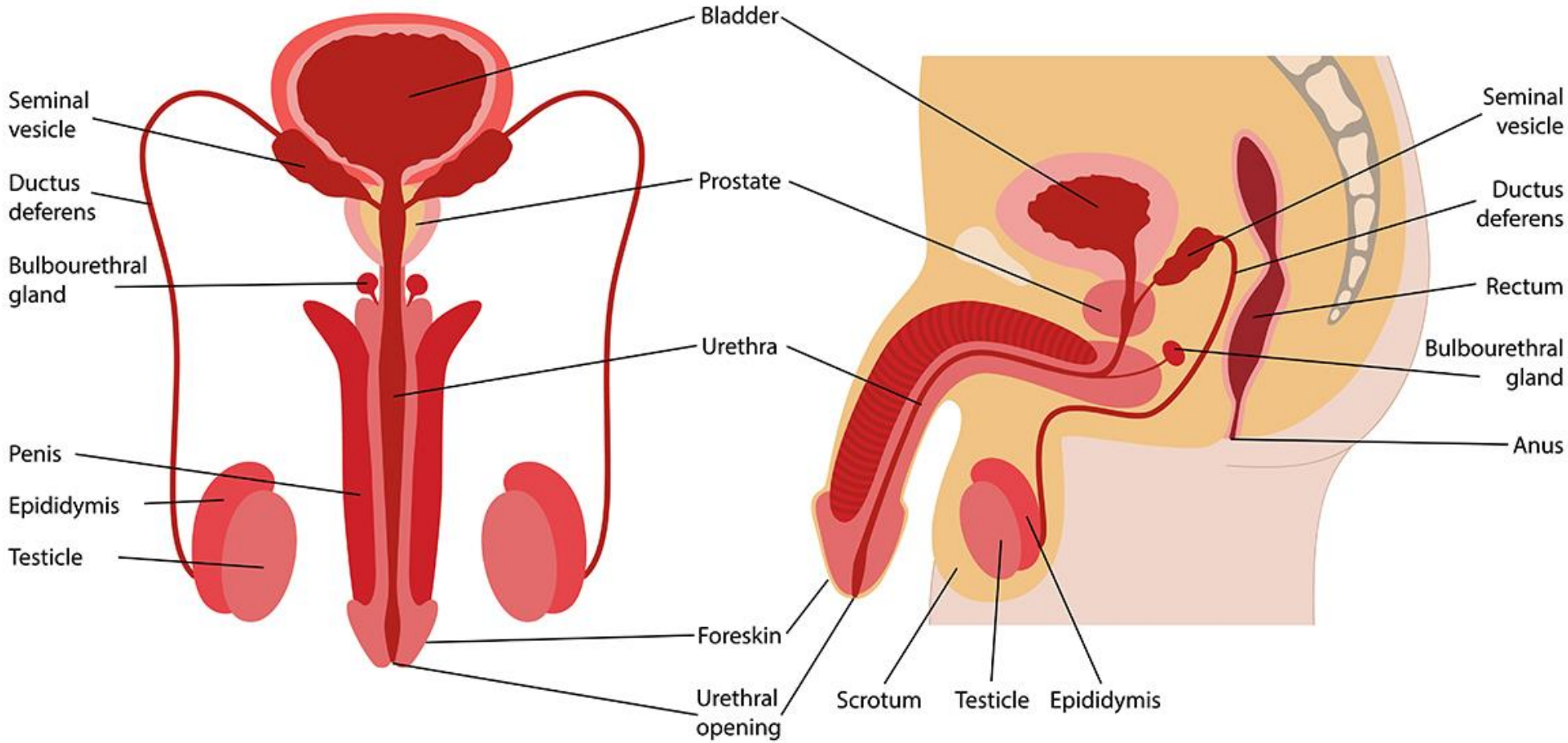
ANATOMY OF THE MALE REPRODUCTIVE SYSTEM

Prof. Mohammad El Khatib

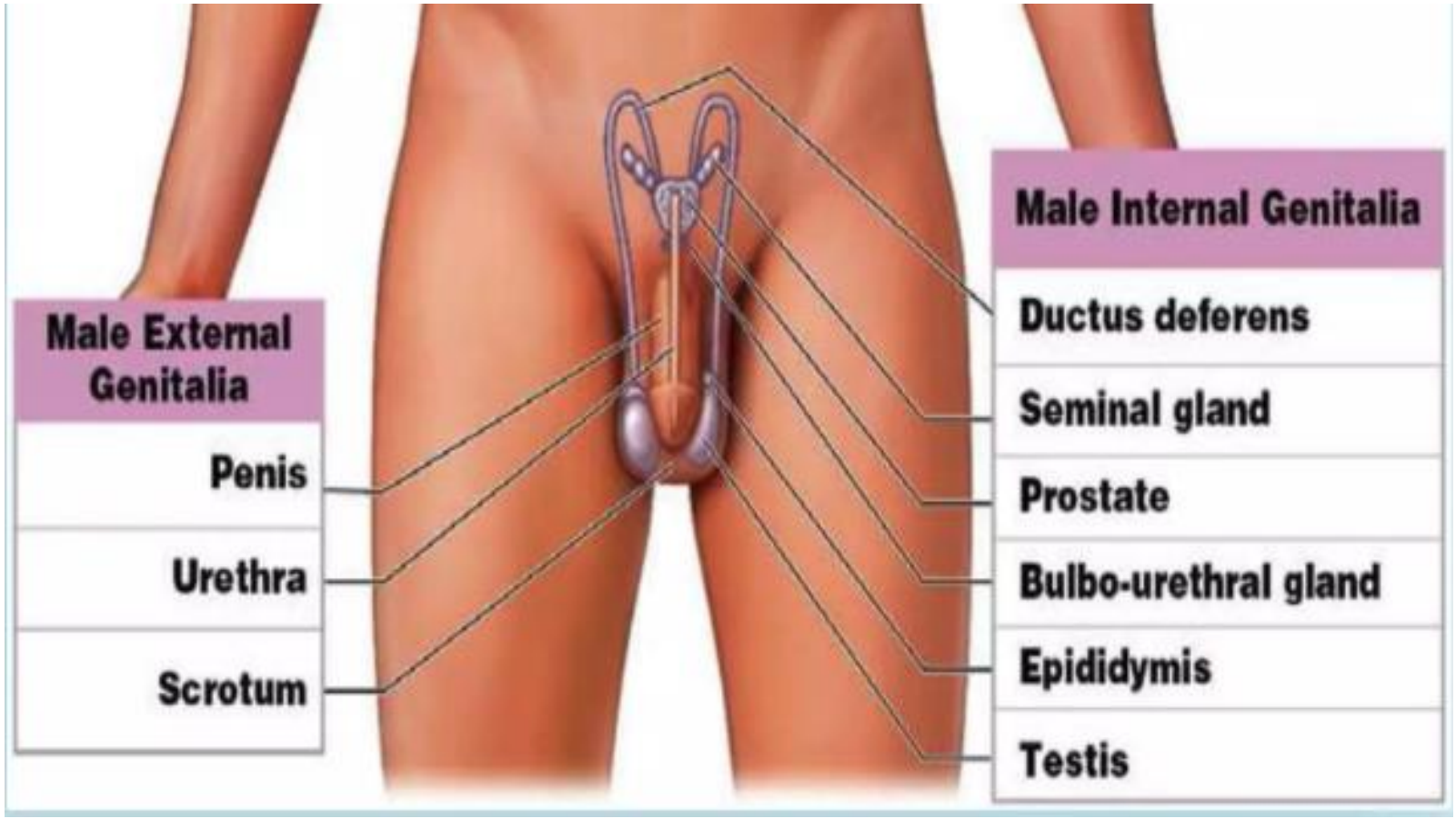
Prof. Annunziata Mauro

Male Reproductive System



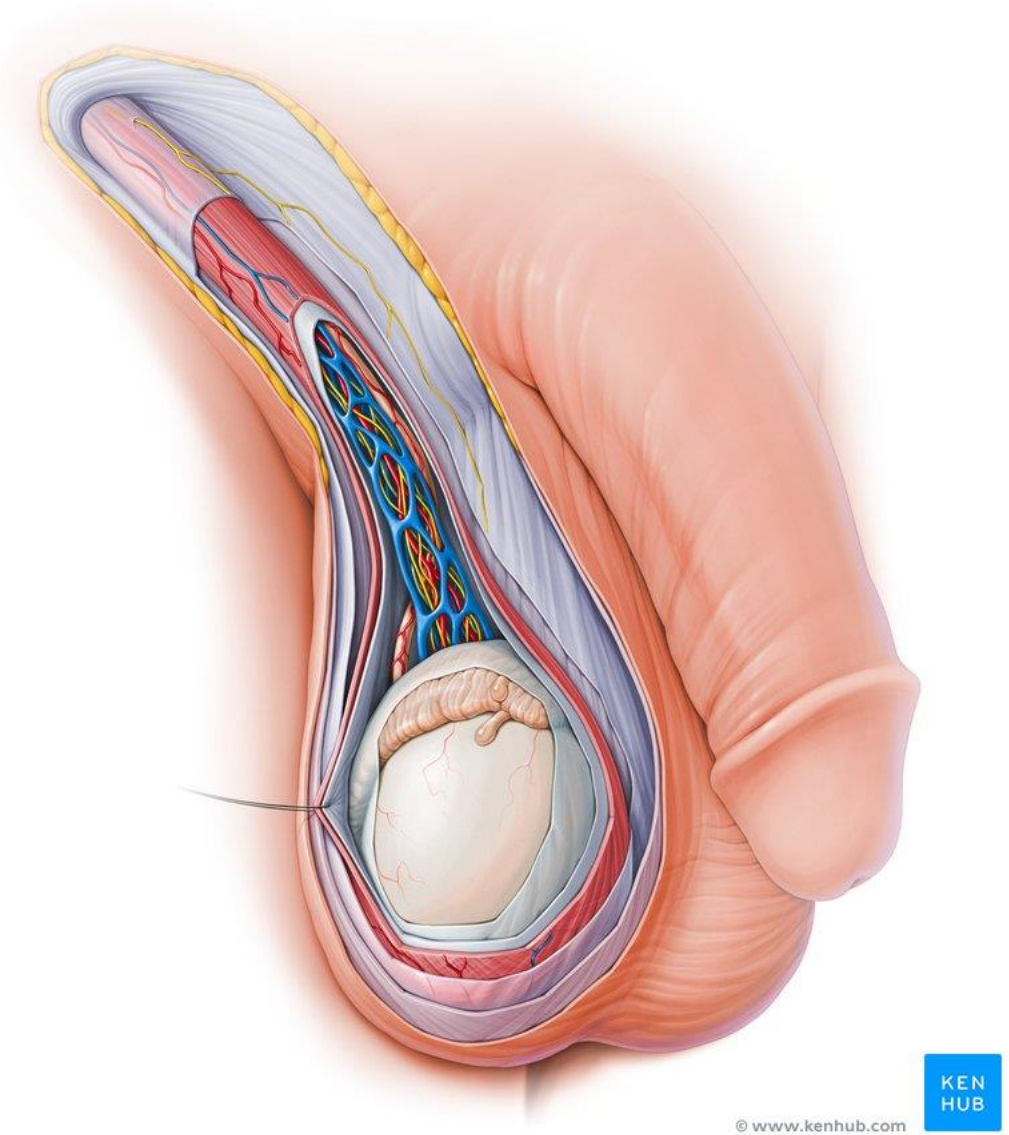
1. MAJOR FUNCTION

- Produce, maintain, and transport sperm (male gametes) and protective semen,
- Secrete male sex hormones (mainly testosterone)
- Discharge sperm into the female reproductive tract for fertilization to produce a zygote.



2. MALE EXTERNAL GENITAL

- Scrotum: main content is the testes
- Penis
- Penile Urethra



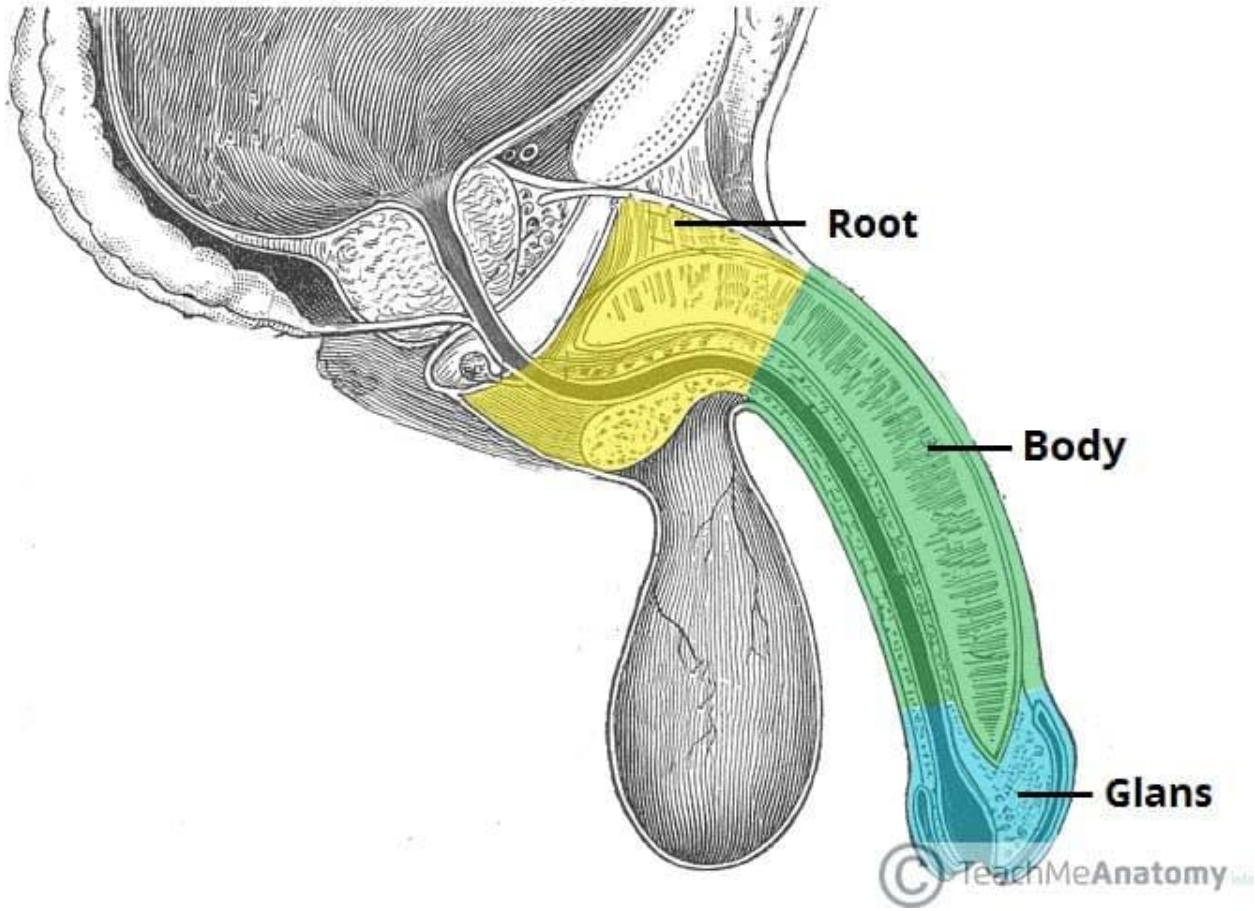
2.A. Penis

•Serves as an external component of the male reproductive system, **fulfilling two primary roles:**

1) Facilitating sexual intercourse
2) Enabling urination

•Anatomically, the penis is divided into three distinct sections:

- •**Root**: The innermost, fixed portion that is not visible externally.
  - •Contains three erectile tissues (two crura and the bulb of the penis) along with two muscles (the ischiocavernosus and bulbospongiosus).
- •**Body**: The free, elongated part that hangs from the pubic symphysis.
  - •Composed of three cylindrical erectile tissues, two corpora cavernosa and one corpus spongiosum.
- •**Glans**: The terminal, expanded tip formed by the distal end of the corpus spongiosum.
  - •Houses the external opening of the urethra (the external urethral orifice).

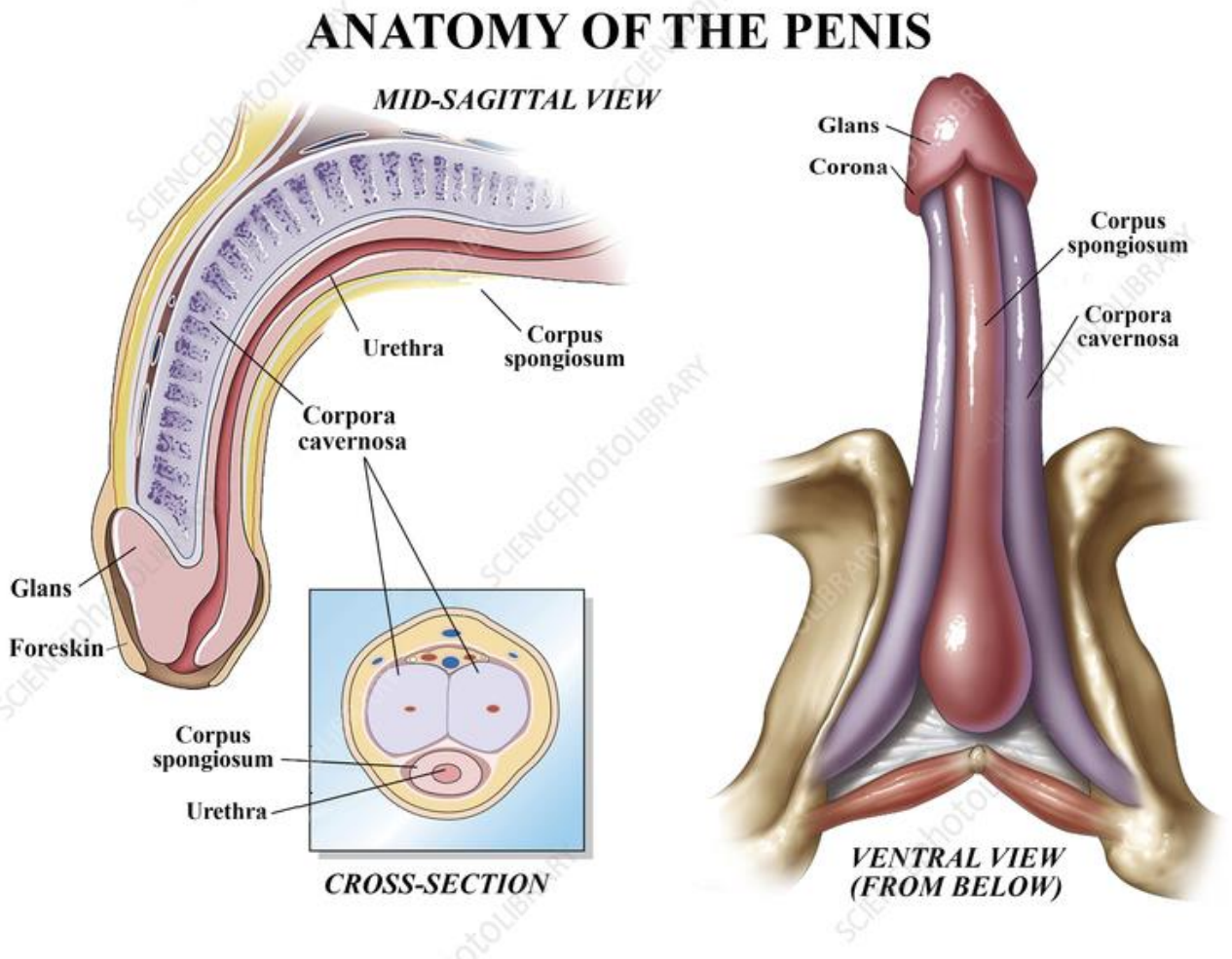


2.A. Penis

- Three cylindrical bodies make up the penis:
  - **Corpora cavernosa**: two erectile bodies surrounded by the tunica albuginea, a dense white fibrous capsule.
  - **Corpus spongiosum**: located ventrally, contains the spongy urethra, and ends in the glans penis.
  - **Crura**: attached to the conjoint rami of the pubis and ischium.

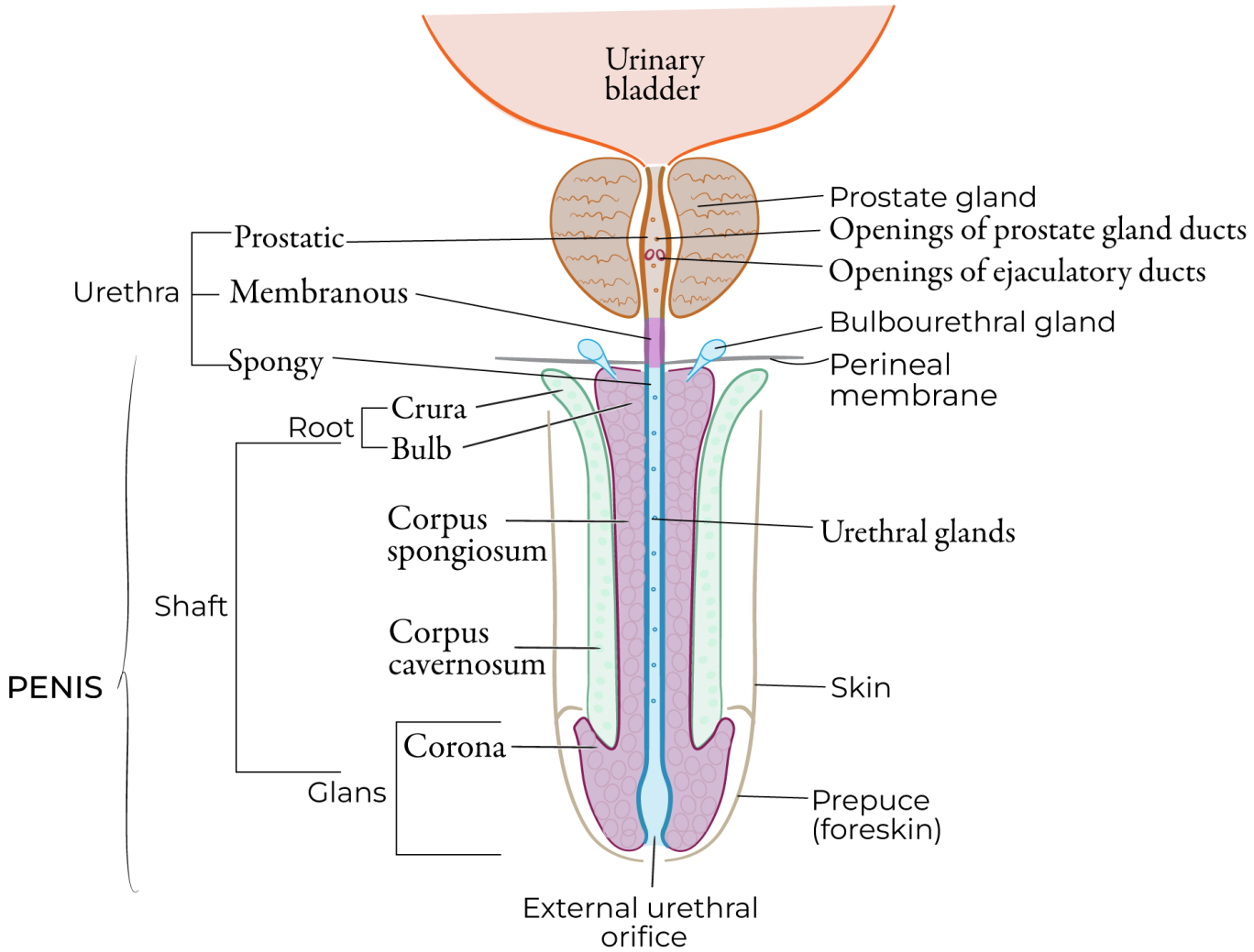
- The root of the penis consists of the bulb, crura, and the bulbospongiosus muscle.

- The main shaft is referred to as the body of the penis.



Penis

Coronal Section



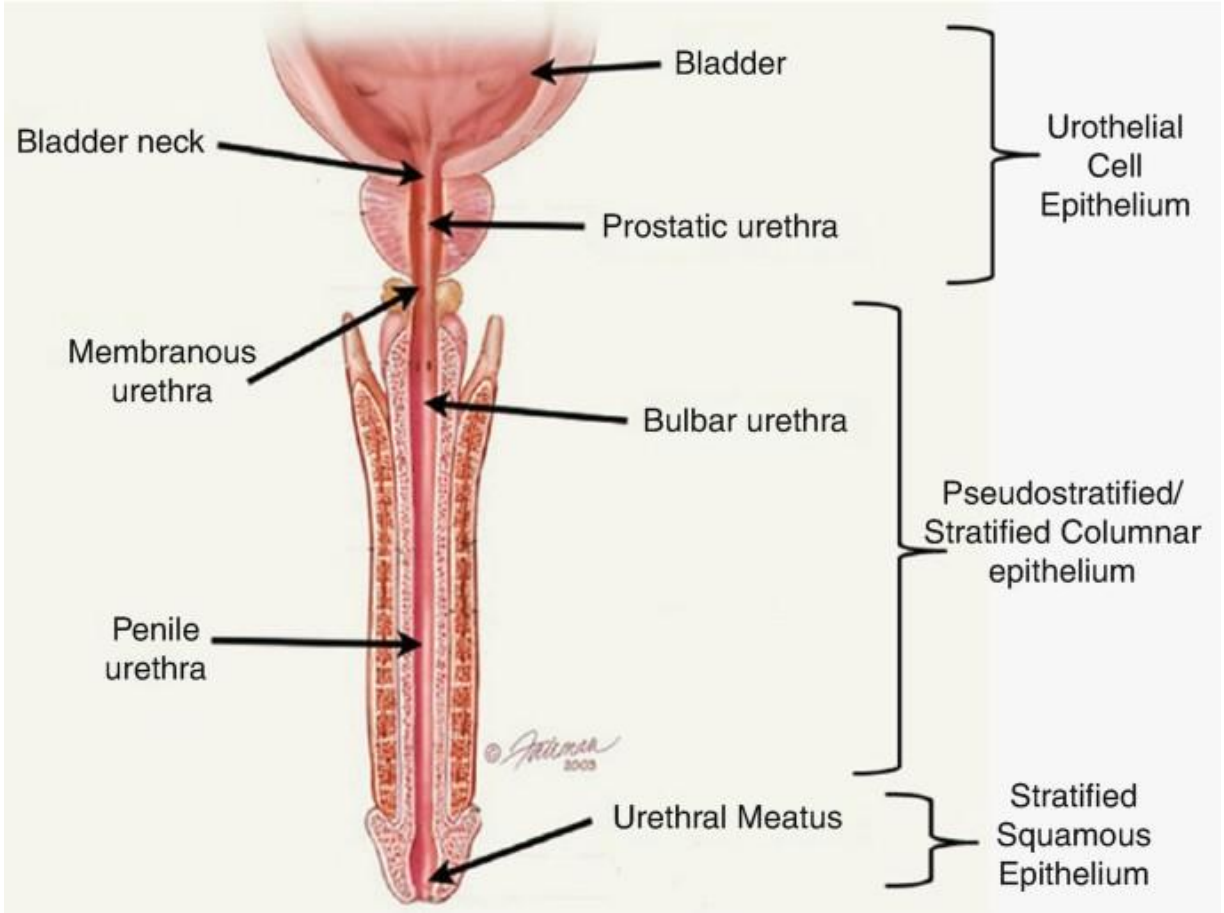
2.B. Male Penile Urethra

•The male urethra measures roughly 15 to 20 centimeters in length, whereas the female urethra is significantly shorter, about 4 centimeters.

•Beyond its role in expelling urine, the male urethra also serves as a passageway for semen.

•Anatomically, the male urethra is segmented into three distinct regions:

- **Prostatic segment:** This portion traverses the prostate gland. It is the site where both the ejaculatory ducts and prostatic ducts empty into the urethra.
- **Membranous segment:** Passing through the pelvic floor and the deep perineal pouch, this section is encircled by the external urethral sphincter, which allows voluntary control over urination.
- **Spongy segment:** Extending through the bulb and corpus spongiosum of the penis, this part concludes at the external urethral opening. Within the glans penis, the urethra widens to form the navicular fossa.



2.C. Scrotum

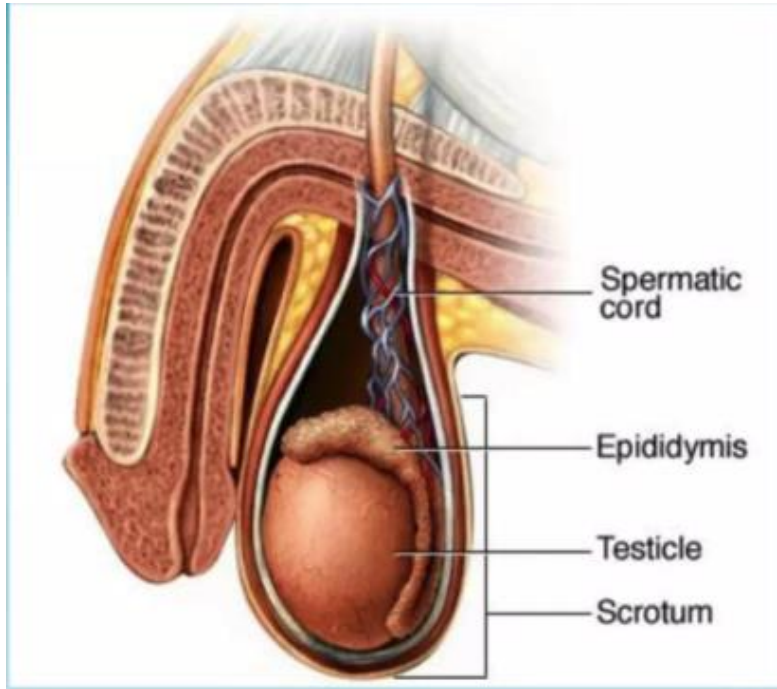
- Loose, pouch-like sac of skin that hangs from the body below the perineum.

- It is a saccular extension of the anterior abdominal wall.

- Contains two testes and their spermatic cords, nerves and blood vessels.

- Protects testicles and provides a sort of “climate-control system.” For normal sperm development, the testes must be at a temperature that’s slightly cooler than body temperature (between 97 and 99 degrees Fahrenheit or 36 and 37 degrees Celsius).

- Special muscles in the wall of the scrotum let it contract (tighten) and relax. The scrotum contracts to move the testicles closer to the body for warmth and protection. It relaxes away from the body to cool them.



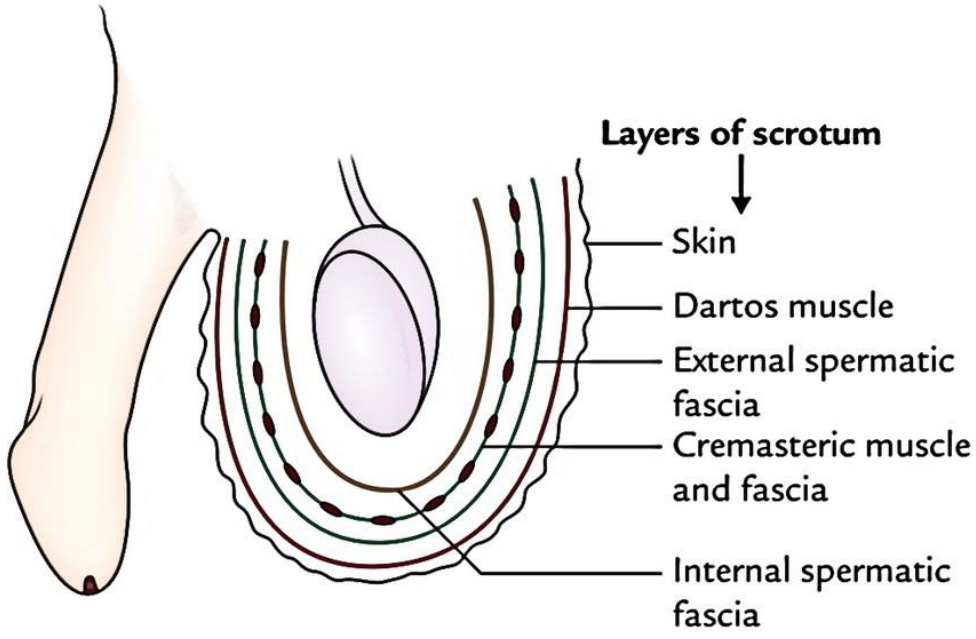
2.C. Scrotum

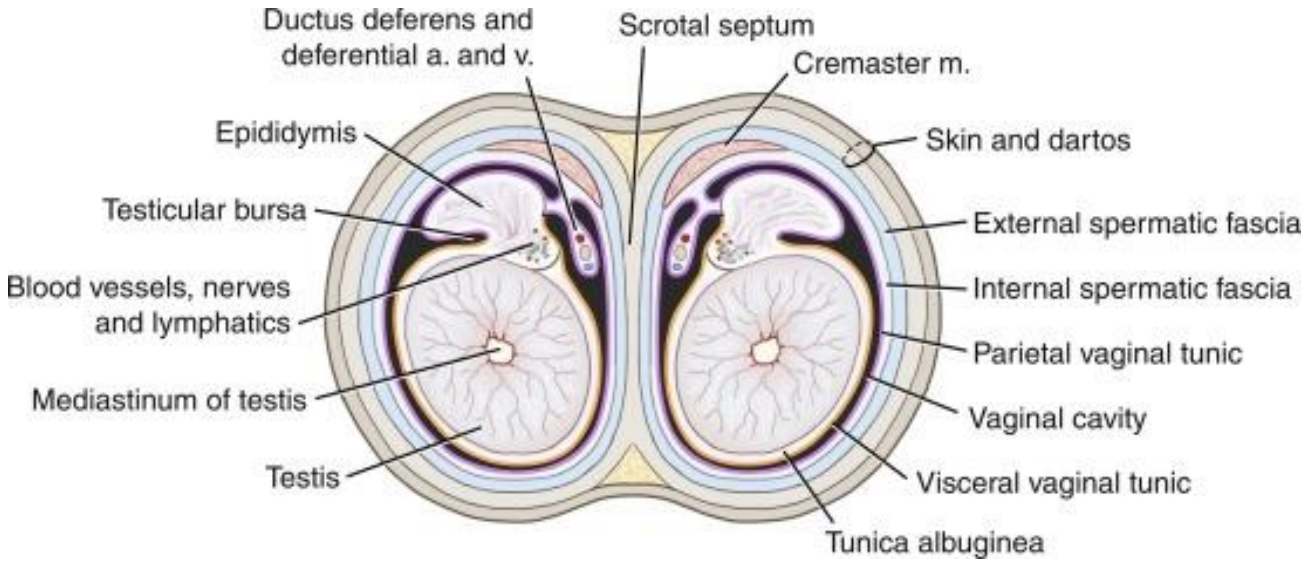
•Scrotum temperature is about **93.2°F (34°C)**, cooler than the body's usual **98.6°F (37°C)**.

•Cooler temperature supports faster sperm formation .

•Layers from superficial to deep: «Some Dangerous Englishmen Called It The Testis»

- •Skin
- •Dartos muscle and fascia
- •External spermatic fascia (from external oblique muscle)
- •Cremasteric muscle and fascia (from internal oblique muscle)
- •Internal spermatic fascia (from transversalis fascia)
- •Tunica vaginalis (peritoneal sac partially enclosing testes)
- •Tunica albuginea



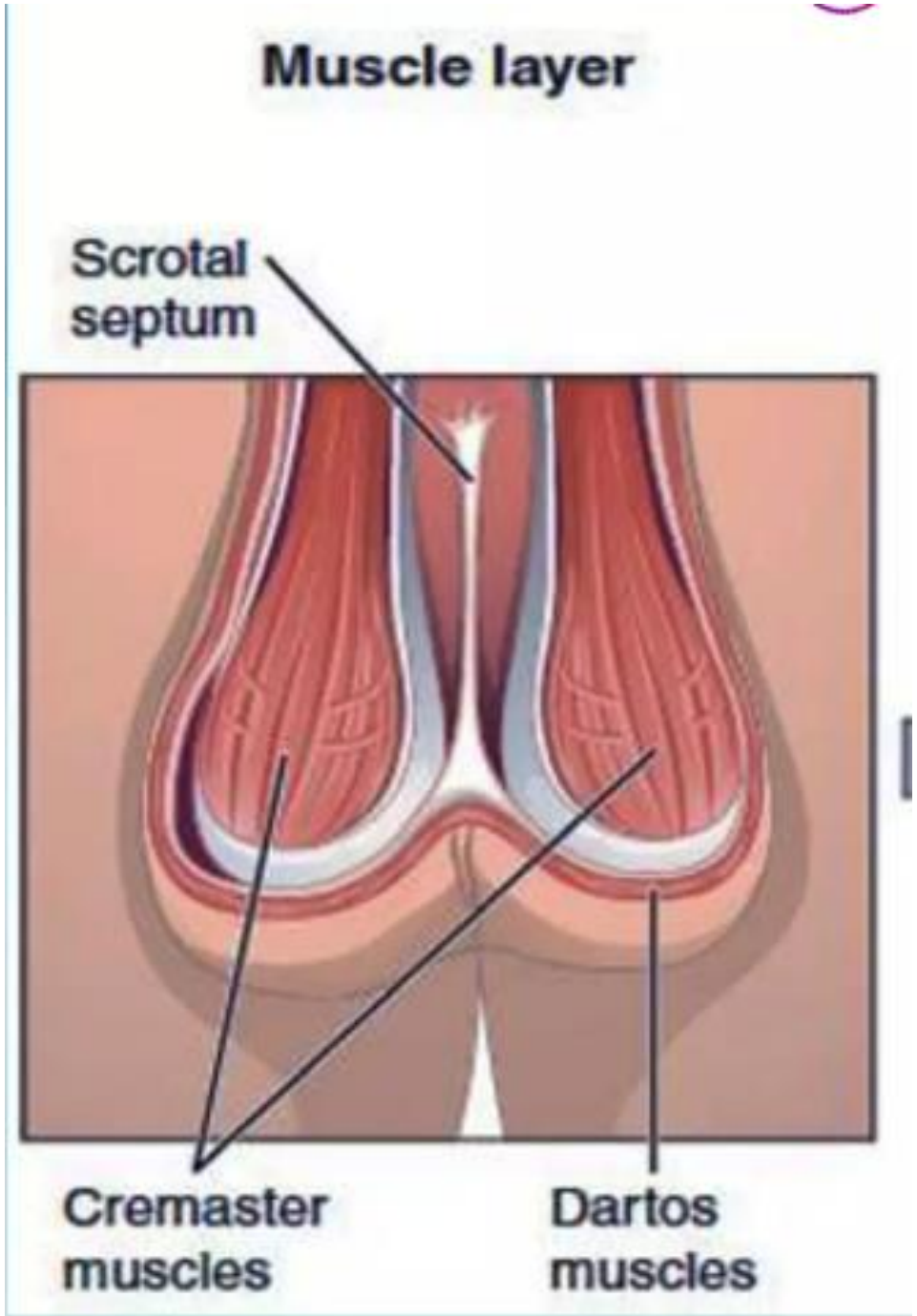


2.C. Scrotum

•The skin of the scrotum is characteristically wrinkled and pigmented, which helps in thermoregulation by increasing surface area and allowing for better heat dissipation. The superficial fascia beneath this skin layer is notably devoid of fat, which facilitates temperature control essential for optimal sperm production.

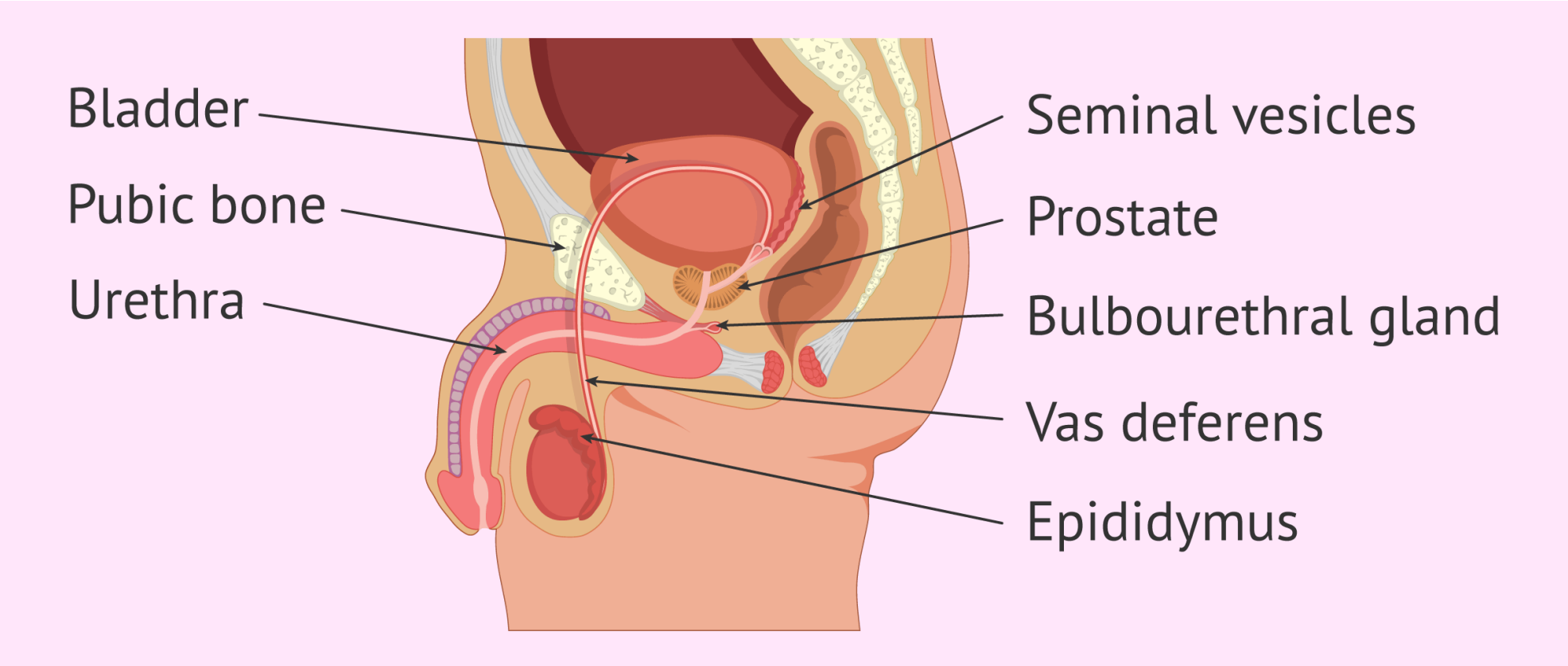
•Two key muscles are associated with the scrotum, each playing a vital role in maintaining the testes at an appropriate temperature:

- **Dartos muscle**
  - •This is a thin layer of smooth muscle located just beneath the skin of the scrotum. It contracts to elevate the testes and create wrinkles on the scrotal surface when the external temperature drops. This wrinkling reduces surface area, helping to conserve heat and protect the testes from cold.
- **Cremaster muscle**
  - •This muscle is composed of skeletal muscle fibers and surrounds the testes and spermatic cord. It functions by pulling the testes closer to the body during sexual arousal or exposure to cold temperatures. This action helps to warm the testes, ensuring the environment remains conducive to sperm viability and function.



3. MALE EXTERNAL GENITAL

- Testis
- Epididymis
- Bulbo-urethral gland
- Prostate
- Seminale gland (Seminal vesicles)
- Vas deferens (Ductus)

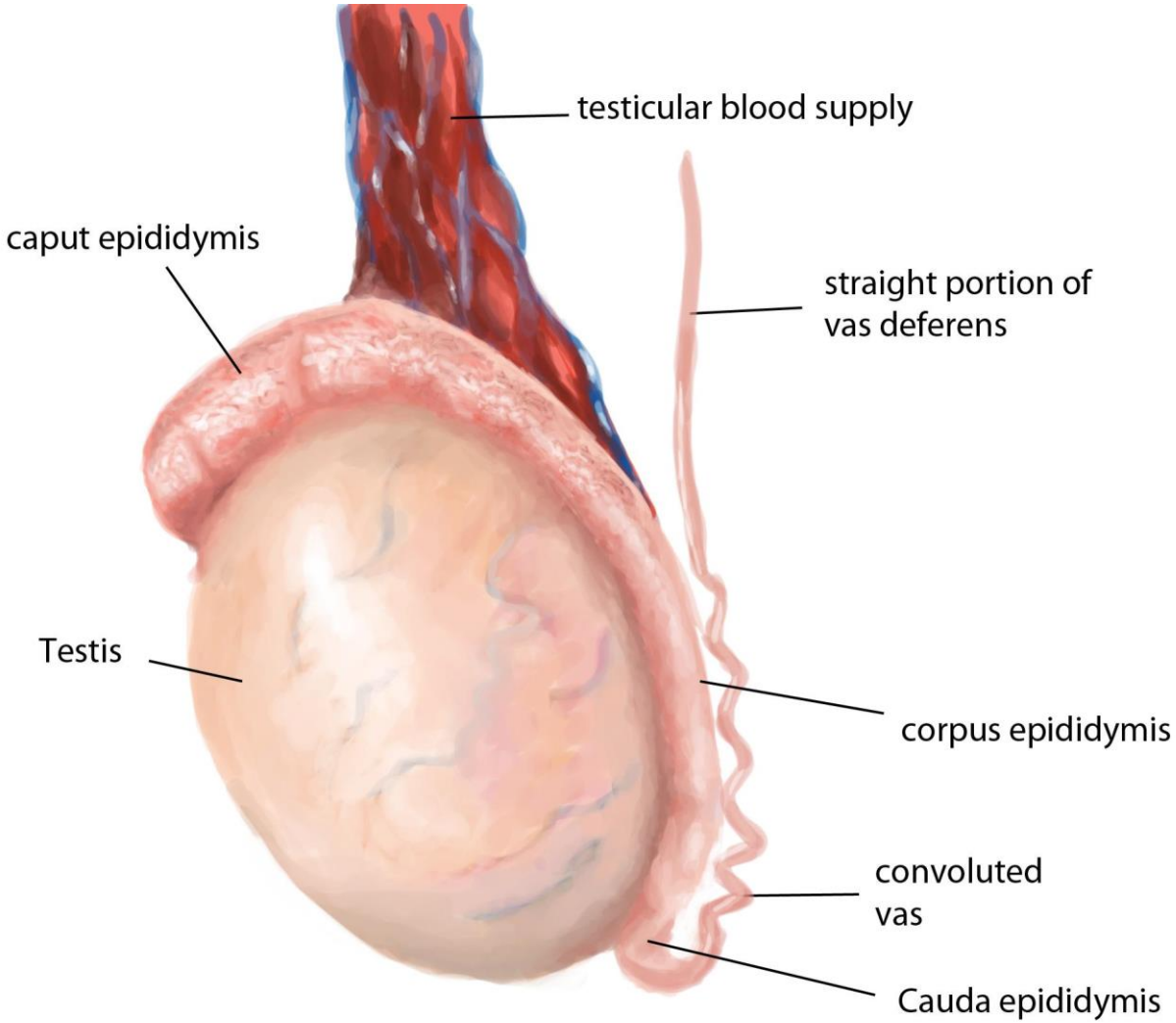


3.A. Testis

• The testis is the primary reproductive organ of the male reproductive system, playing a crucial role in both sperm production and hormone secretion.

• The testis is the male gonad, homologous to the ovary in females, meaning they share a common embryonic origin and perform analogous functions in their respective sexes.

• They produce sex hormones called ANDROGENS, with testosterone being the most significant, which are essential for the development of male secondary sexual characteristics and the regulation of reproductive functions.

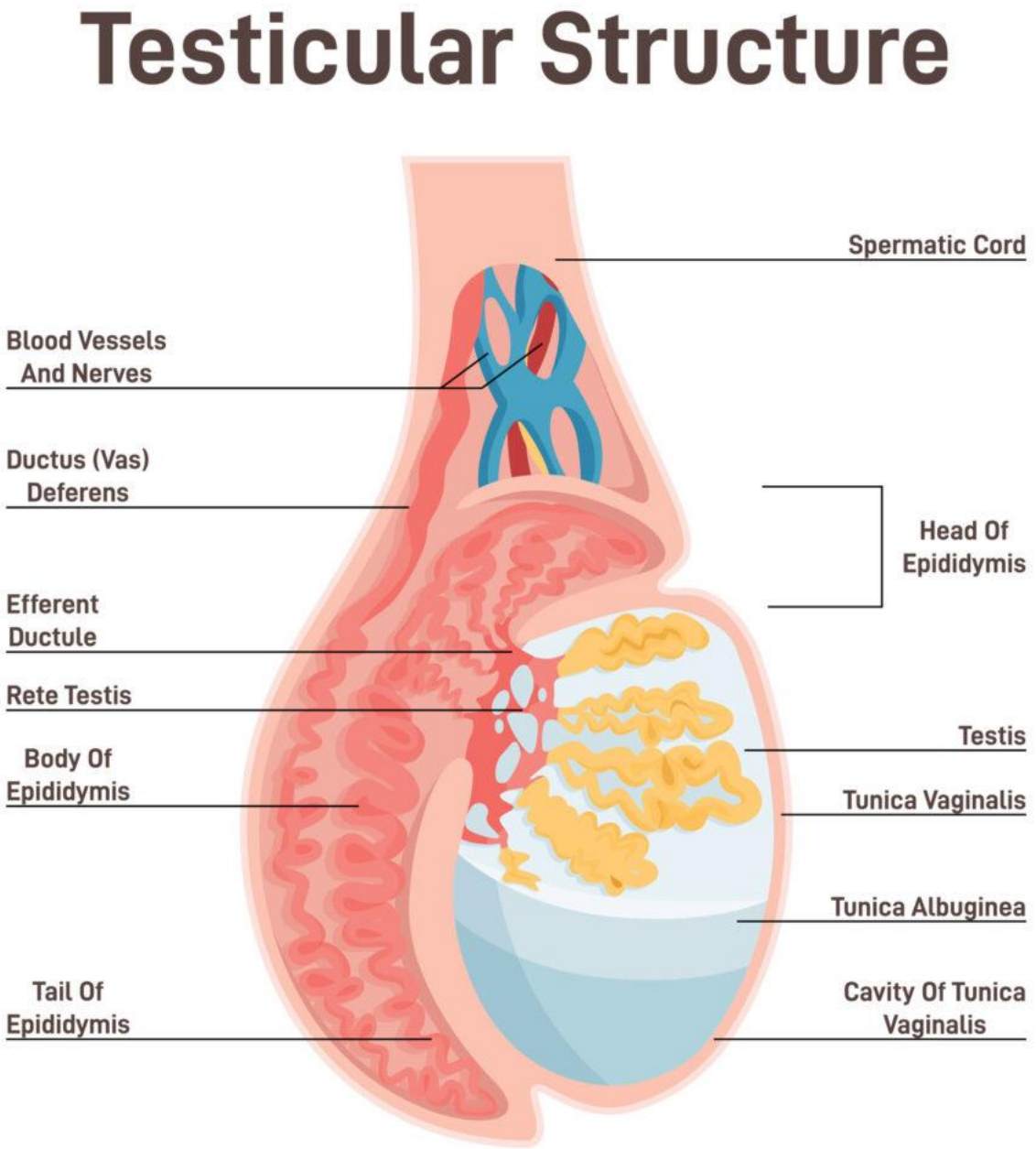


3.A. Testis

• Each testis is an oval-shaped structure, approximately 5 cm long and 3 cm in diameter, enclosed within a protective fibrous capsule called the tunica albuginea.

• An adult testis typically weighs between 10 to 15 grams and contains numerous seminiferous tubules where sperm production (spermatogenesis) occurs.

• The testes are suspended in the scrotum, which helps regulate their temperature, a vital factor for optimal sperm development.



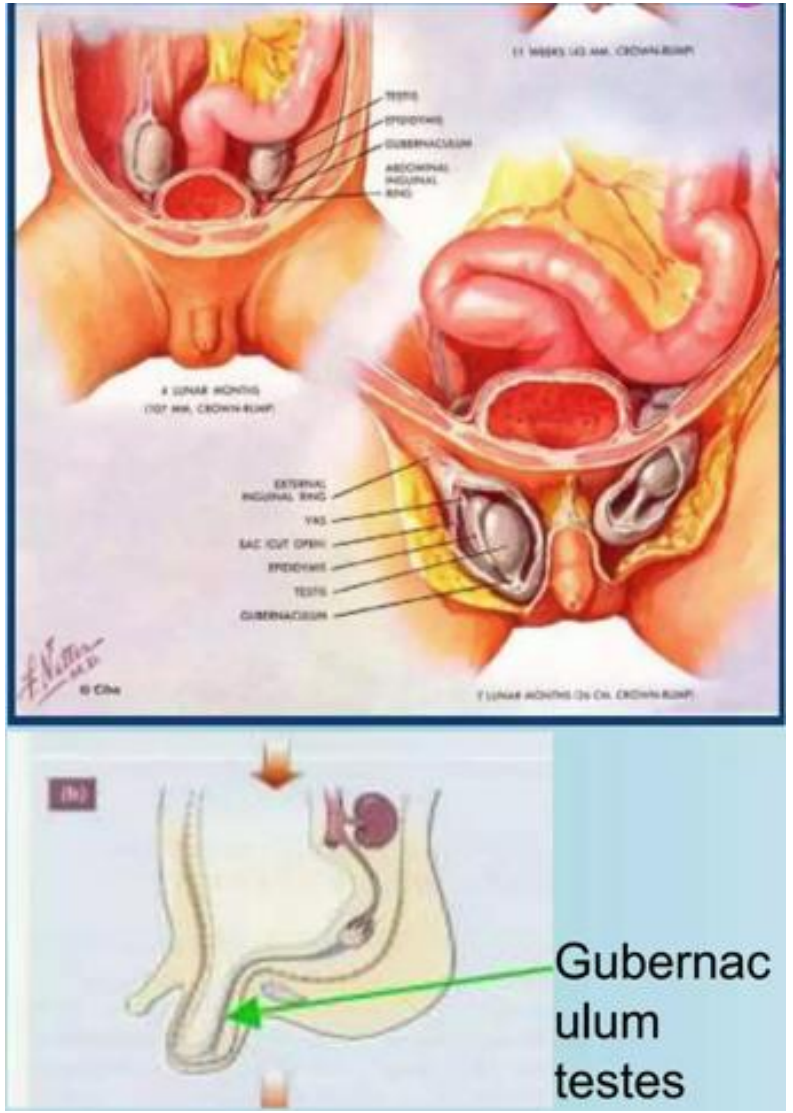
3.A. Testis

- The testes develops retroperitoneal on the posterior abdominal wall and descend into the scrotum just before birth.

- During development, its decent is believed to be guided by the Posterior gonad ligament (Gubernaculum). This ligament acts as a physical guide during fetal development, anchoring the testes and preventing them from moving upward as the body grows. Its shortening effectively pulls the testes through the inguinal canal, a passageway in the lower abdominal wall, ensuring they reach the scrotum at the right time.

- The mullerian inhibiting hormone, produced by the Sertoli cells in the developing tests, plays a key role in male sexual differentiation by causing the regression of the Mullerian ducts, which would otherwise develop into female reproductive structures. Additionally, it supports the transabdominal movement of the testes during early development.

- If one or both testes fail to descend into the scrotum, the testosterone production continues, however, the higher internal body temperature can impair sperm production, leading to reduced fertiliy and increased risk of testicular cancer if left untreated. This is called «undescended testes» or «cryptorchidism».



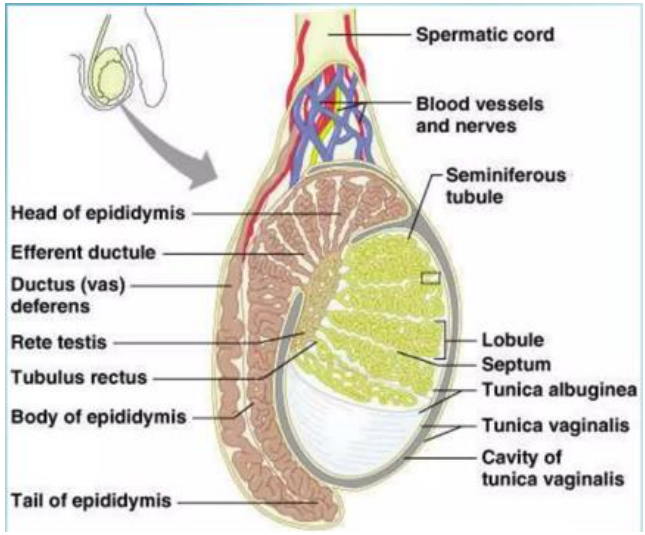
3.A. Testis

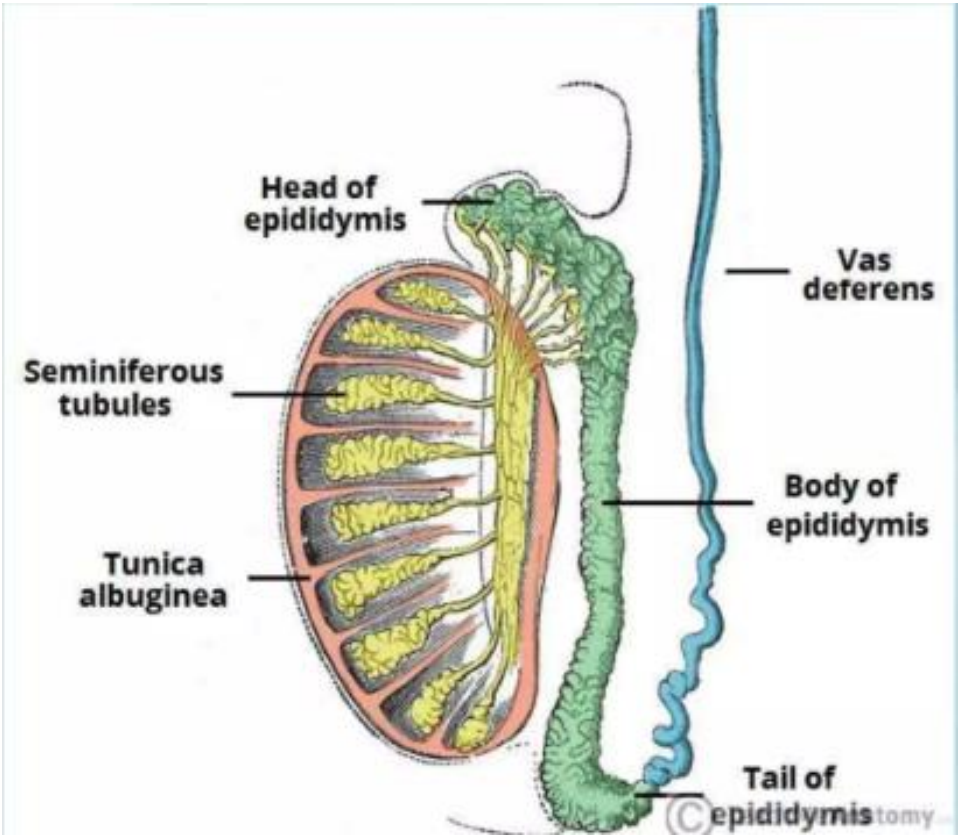
- The testes are covered by a tough, fibrous capsule known as the **tunica albuginea**. This dense layer not only protects the delicate internal structures but also plays a crucial role in maintaining the shape and integrity of each testis.

- Surrounding the tunica albuginea is the **tunica vaginalis**, a serous membrane derived from the peritoneum. This layer forms a protective sac around the testis, providing a slippery surface that reduces friction as the testes move within the scrotum, which is essential for temperature regulation and protection.

- Each testis is suspended within the scrotum by the **spermatic cord**, a vital structure containing blood vessels, nerves, lymphatics, and the vas deferens. This cord not only supports the testis but also facilitates the transport of sperm and supplies necessary nutrients and oxygen.

- The testis is anchored to the floor of the scrotum by the **scrotal ligament**, which is a remnant of the **gubernaculum testes**. During fetal development, the gubernaculum guides the descent of the testes from the abdomen into the scrotum, and its remnant helps maintain the position of the testes after birth.





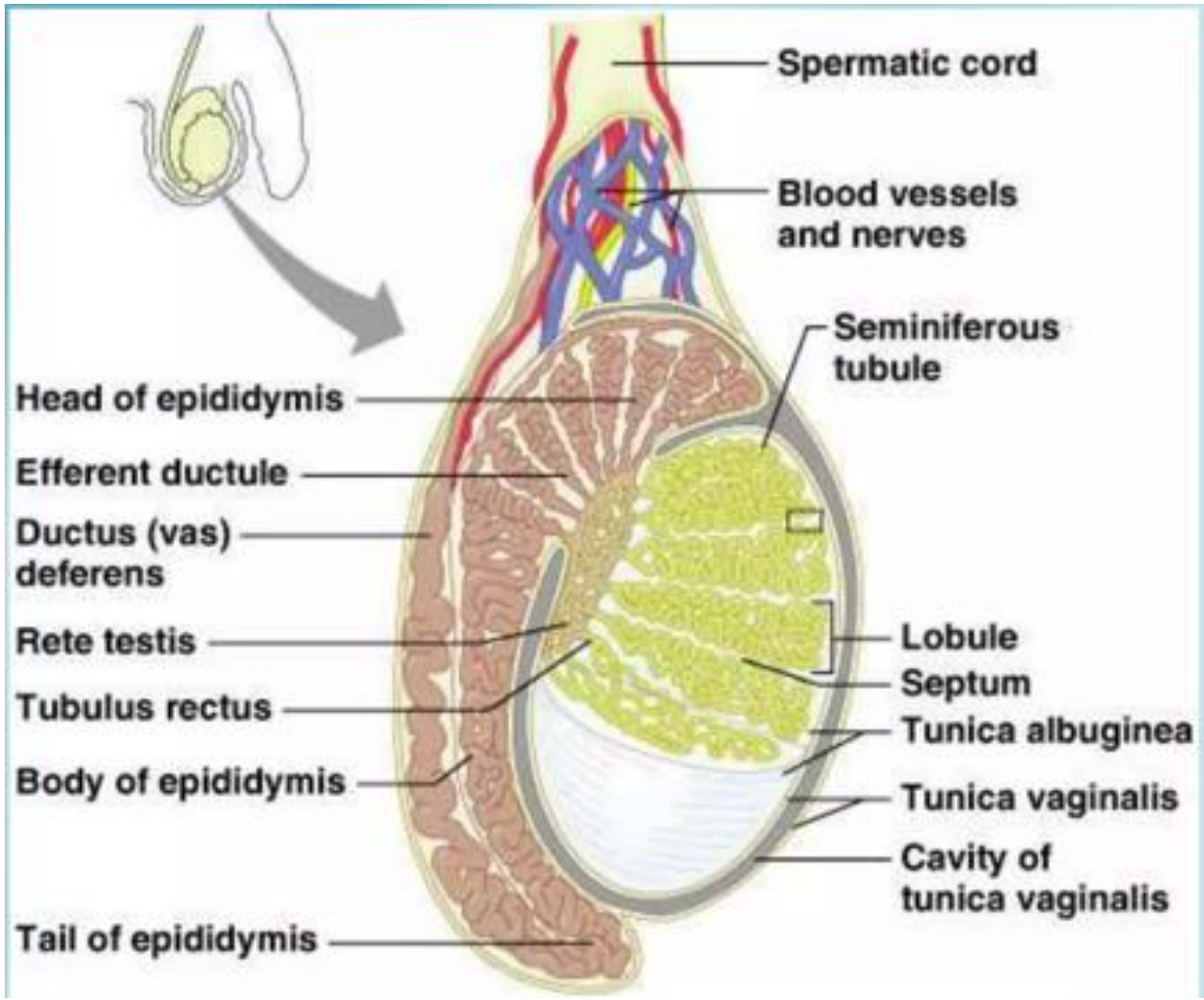
3.A. Testis

Tunica Albuginea and Septa

The tunica albuginea is a dense, fibrous connective tissue layer that envelops the testis. From this tough outer covering, inward extensions called septa (or partitions) arise. These septa divide the testis into numerous compartments known as lobules, typically numbering between 250 and 400. This compartmentalization is crucial for organizing the internal structure and facilitating efficient sperm production.

Lobules and Seminiferous Tubules

Each lobule houses three to four highly coiled seminiferous tubules. These tubules are the site of spermatogenesis, where sperm cells are produced and begin their development. The coiled nature of these tubules maximizes the surface area within the limited space of the lobule, enhancing the production capacity.



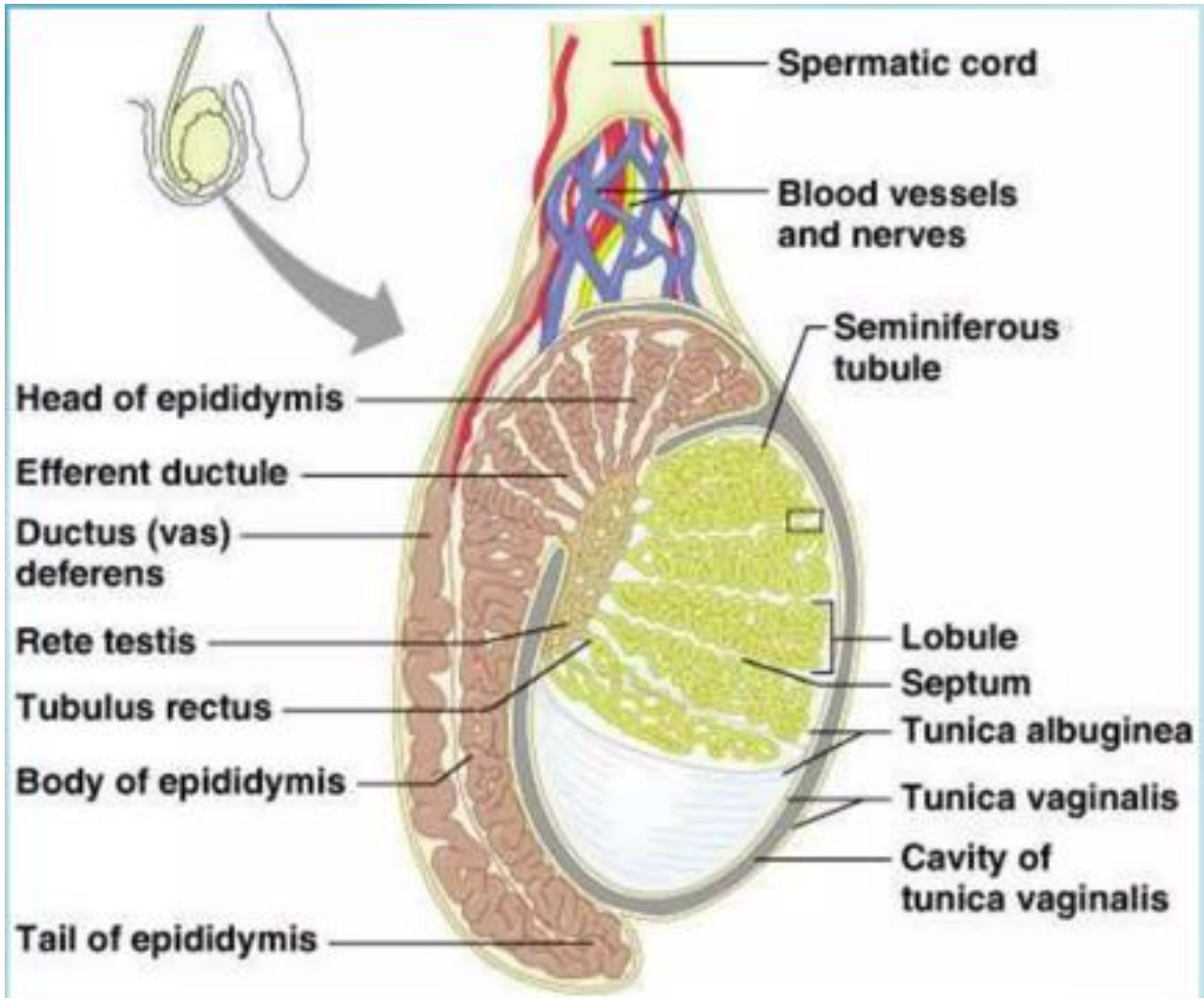
3.A. Testis

Rete Testis

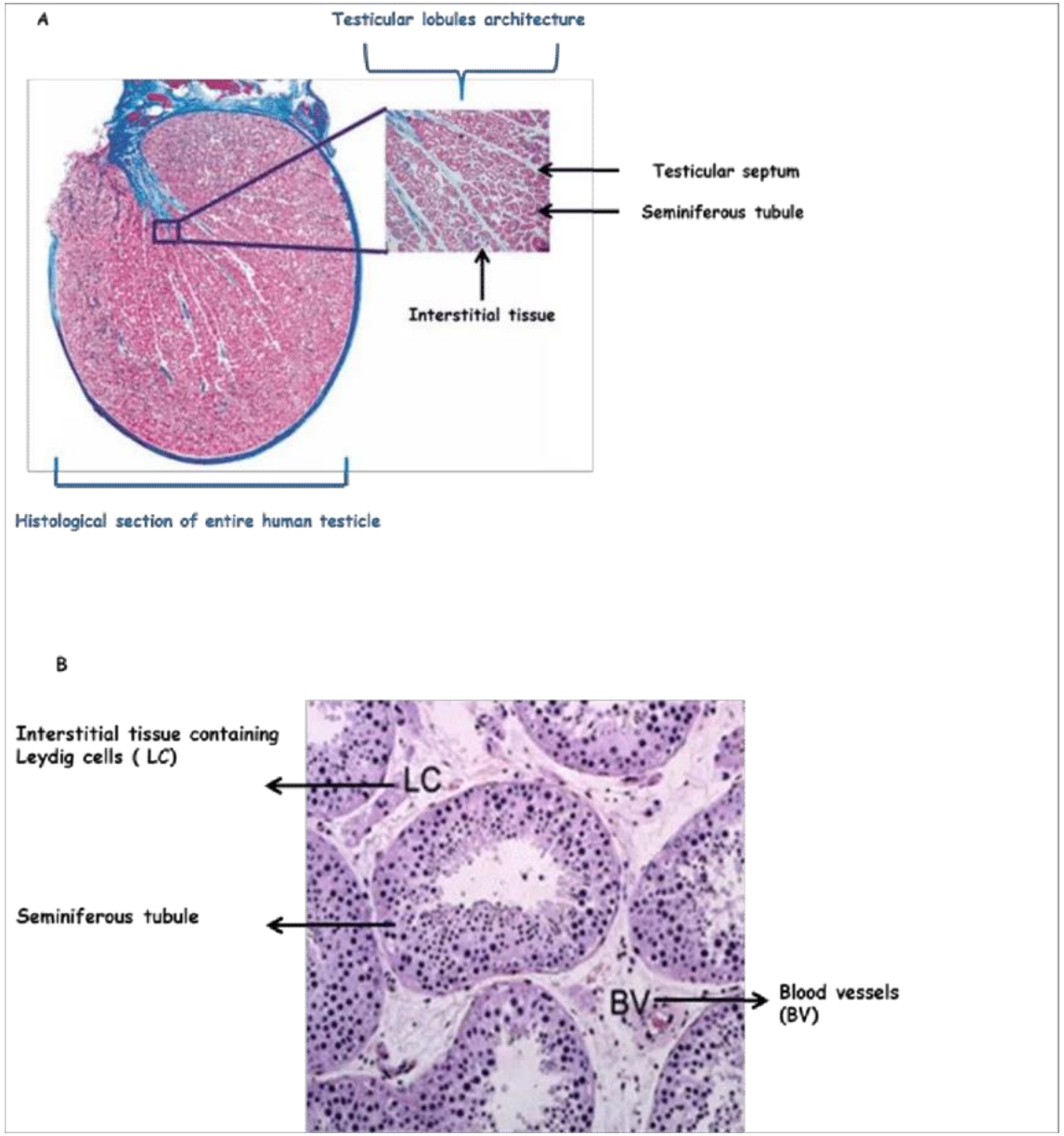
The seminiferous tubules within each lobule converge to form a network called the rete testis. This network acts as a collecting area for spermatozoa exiting the seminiferous tubules. Located outside the lobules but still within the testis, the rete testis channels sperm into the next stage of the reproductive tract.

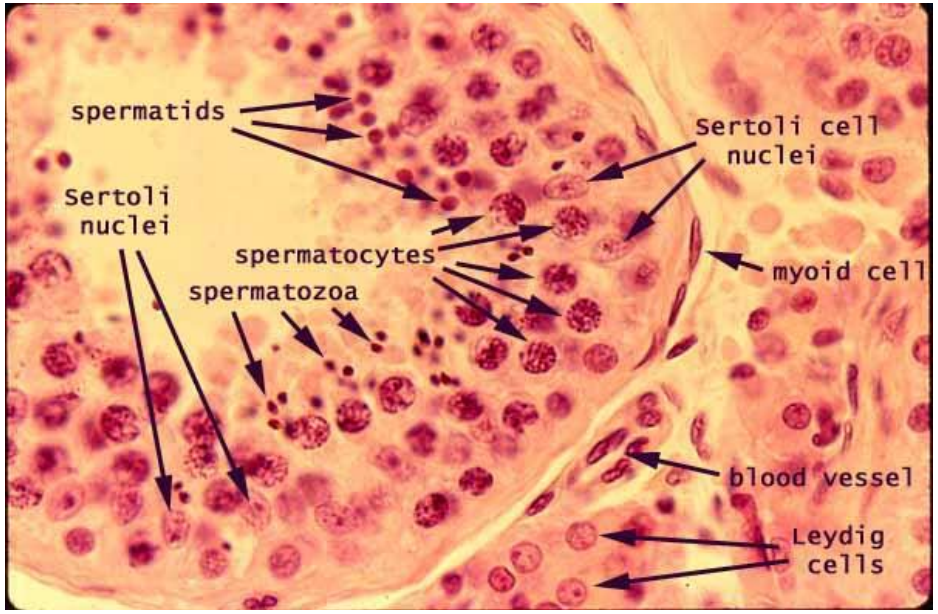
Efferent Ductules and Epididymis

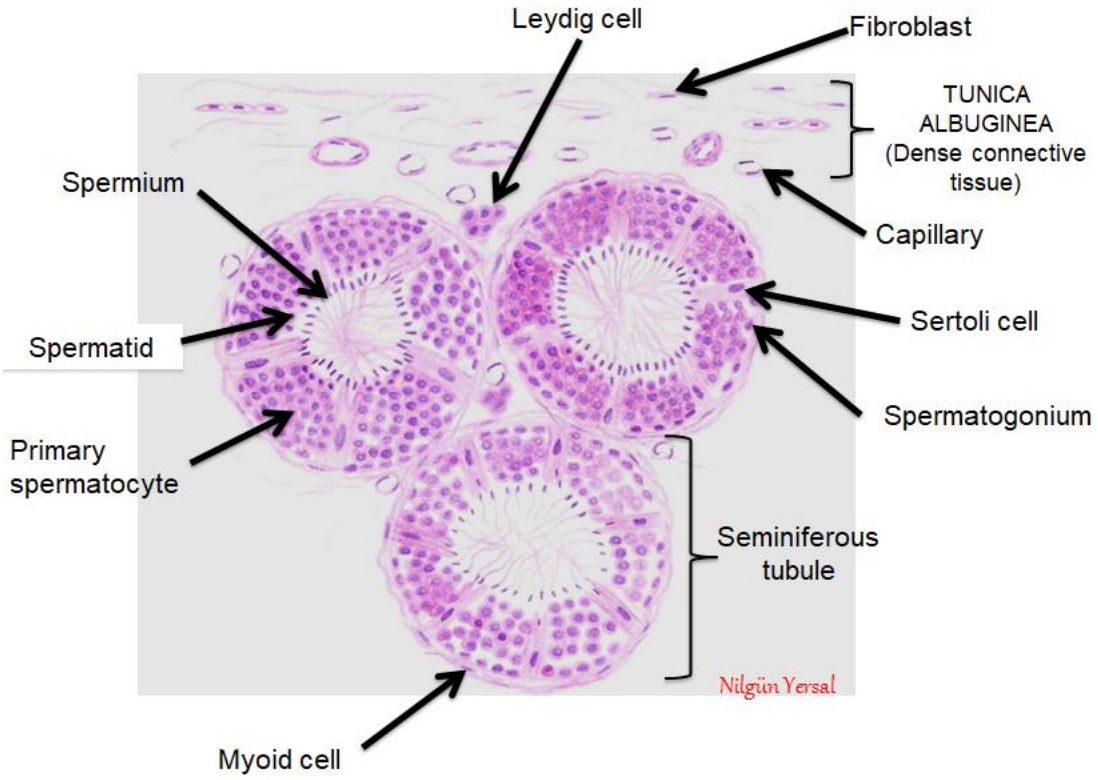
From the rete testis, sperm travel through small ducts known as efferent ductules. These ductules serve as conduits, leading sperm from the rete testis to the epididymis. The epididymis is a long, coiled tube where sperm mature and are stored until ejaculation.



3.A. Testis (microscopic Histology)





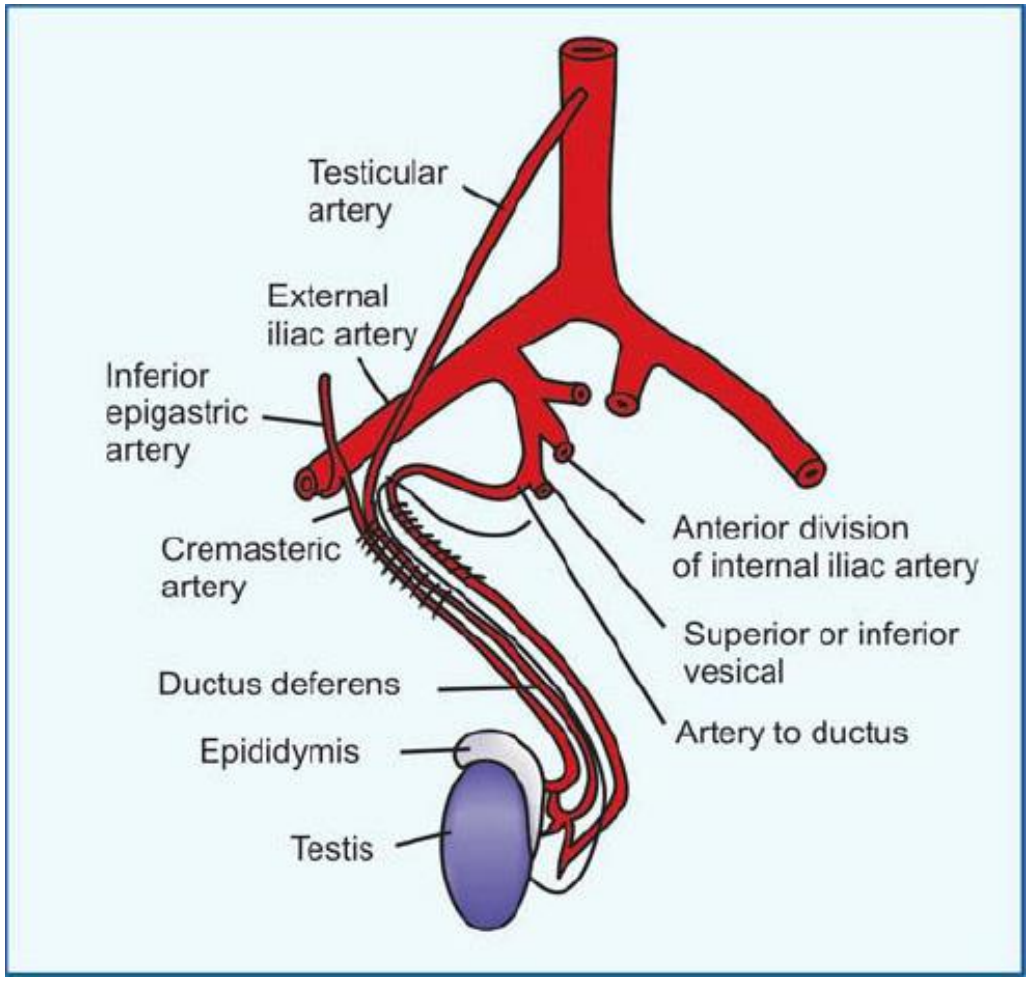


3.A.1. Vascular Supply

•The testes and epididymis receive their primary blood flow from several key arteries:

- **The paired testicular arteries**, which originate directly from the abdominal aorta. These arteries travel downward through the abdomen and enter the scrotum via the inguinal canal, enclosed within the spermatic cord.
- **The cremasteric artery**, branching off from the inferior epigastric artery.
- **The artery of the vas deferens**, which stems from the inferior vesical artery.

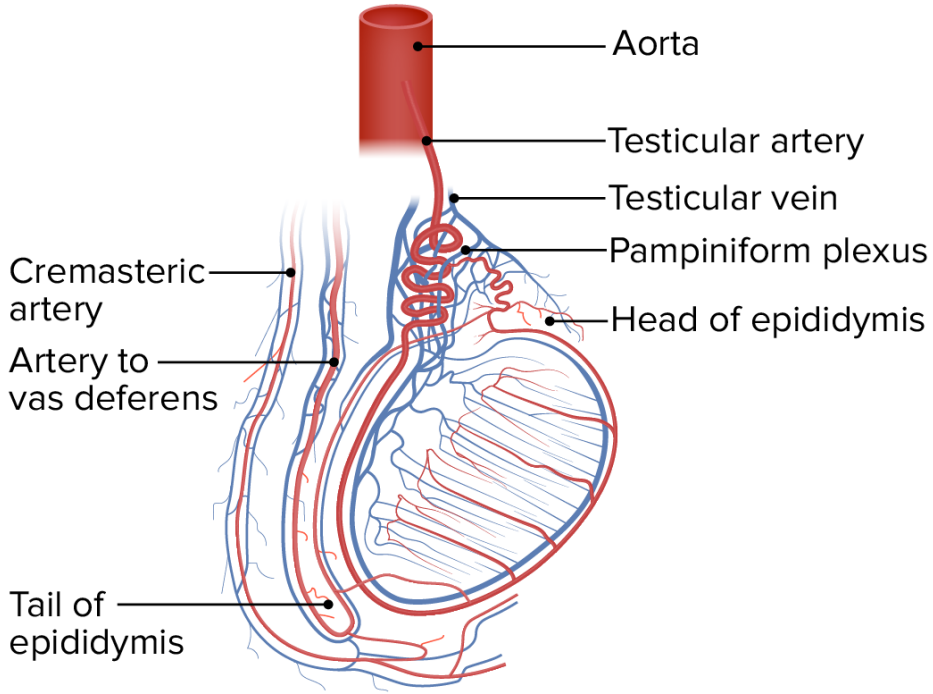
•These vessels form interconnected networks (anastomoses) that support the main testicular artery, ensuring robust circulation.

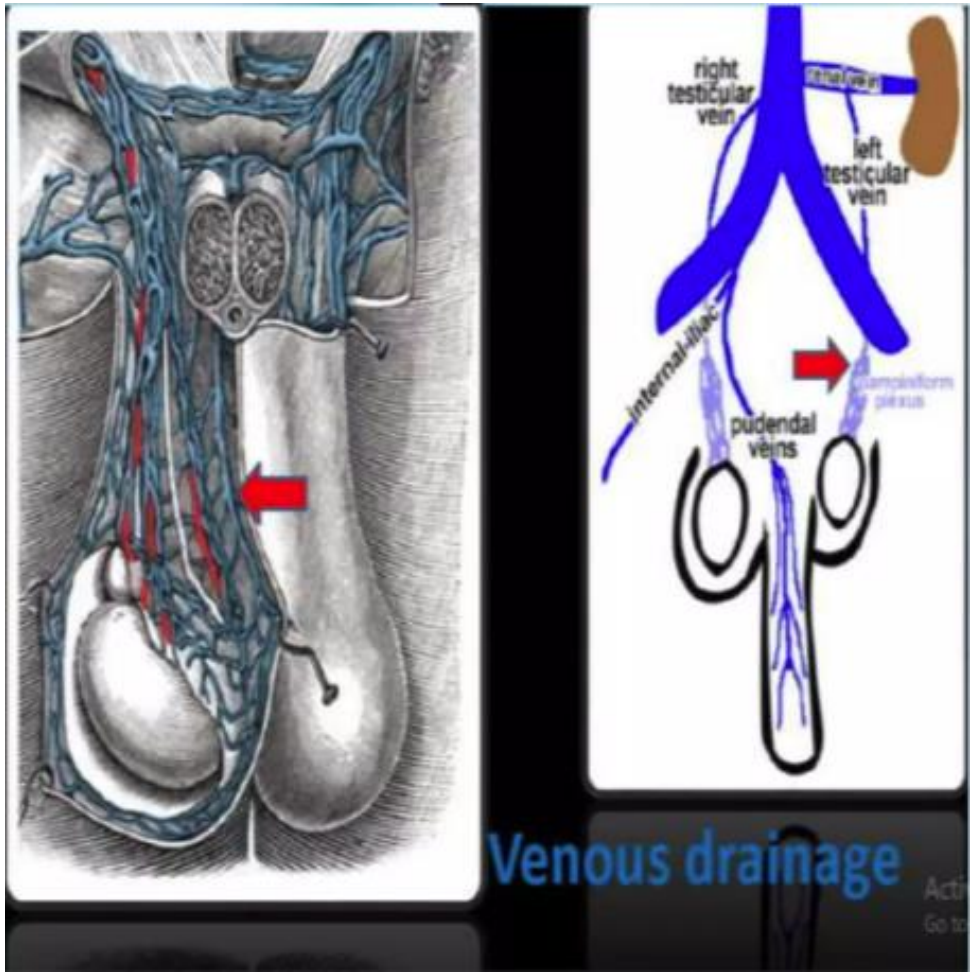


3.A.2. Venous Drainage

•Venous return from the testes occurs through the paired testicular veins, which originate from the pampiniform plexus located within the scrotum.

•The left testicular vein empties into the left renal vein, whereas the right testicular vein drains directly into the inferior vena cava.





3.A.3. Lymphatic Drainage

The lymphatic ascend along the testicular vessels and drain into the **pre-aortic** and **para-aortic groups of lymph nodes.**

Testis

•Lymphatics ascend with the **testicular vessels (spermatic cord)**

•Drain into **para-aortic (lumbar) lymph nodes (L1–L2)**

•Reflects **abdominal embryological origin**

Scrotum

•Drains into **superficial inguinal lymph nodes**

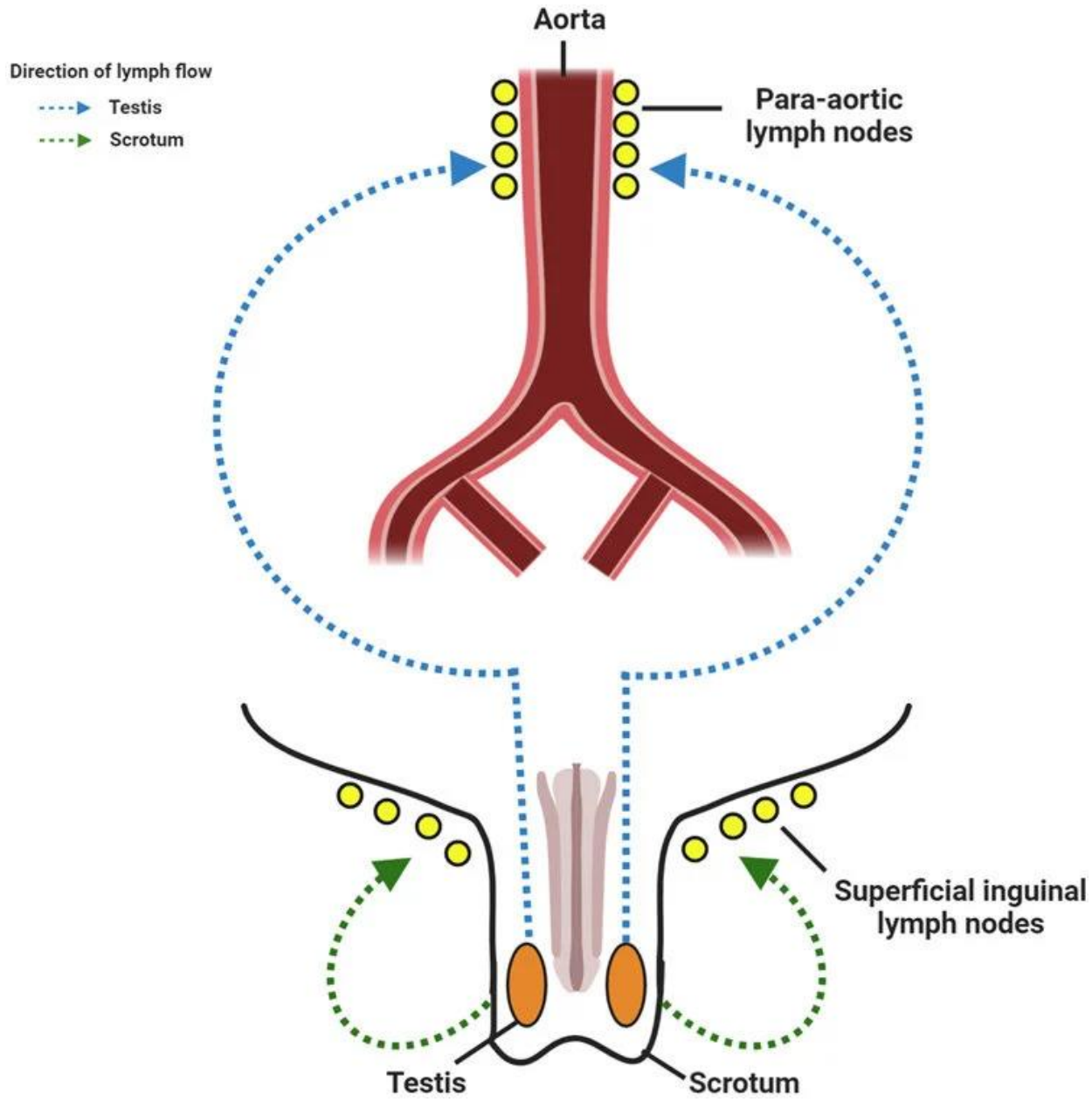
•Follows **body wall (cutaneous) drainage pattern**

•

Clinical Relevance

•Testicular pathology → **para-aortic nodes**

•Scrotal pathology → **inguinal nodes**



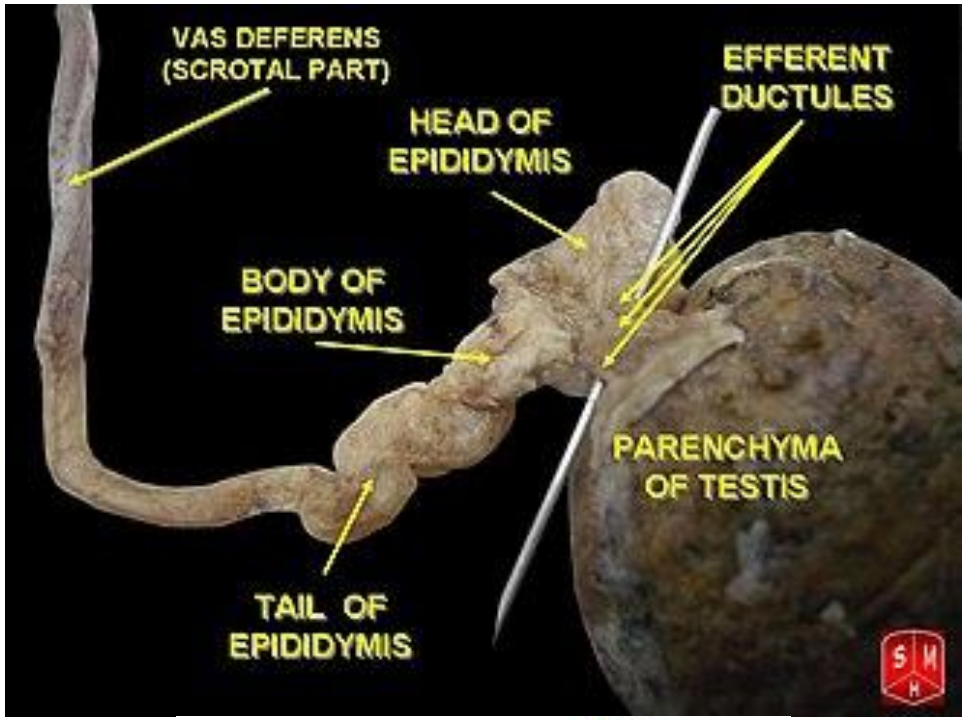
3.B. Epididymis

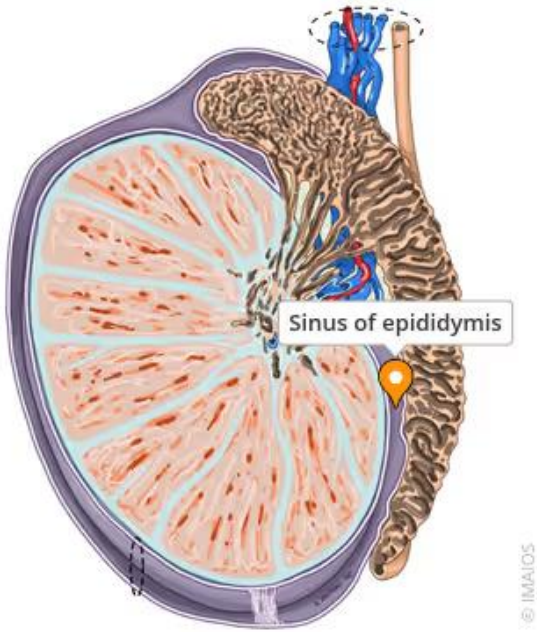
•Positioned firmly behind the testis, the epididymis has the vas deferens running along its inner (medial) side.

•It features a broadened upper section known as the Head, a central portion called the Body, and tapers down to a pointed Tail at the bottom.

•On its outer side, a noticeable groove separates the epididymis from the testis; this groove is lined by the inner visceral layer of the tunica vaginalis and is referred to as the Sinus of the Epididymis.

•Its primary roles include receiving immature sperm (non-motile up to 24h and then become motile), serving as a reservoir for sperm (>1 month) and providing an environment for their maturation.





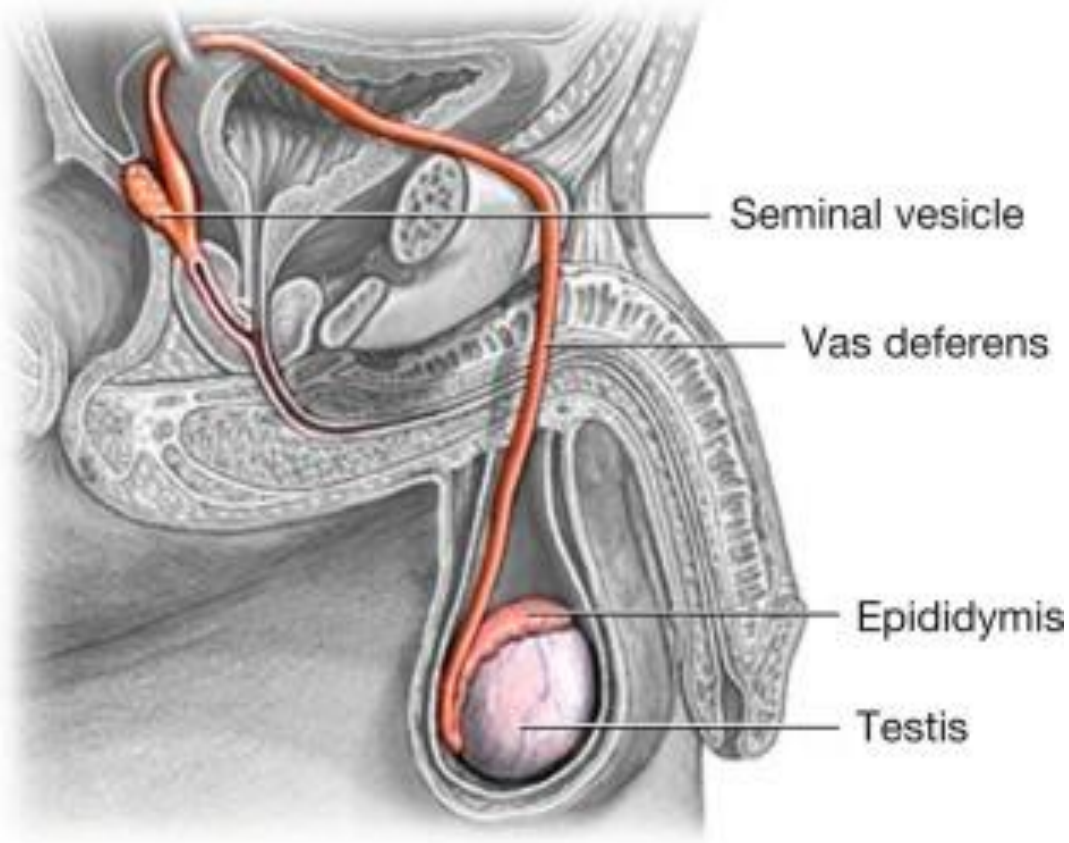
3.C. Vas Deferens (Ductus Deferens)

- The vas deferens is a narrow, muscular tube that extends from the epididymis, which is located on the back of each testicle, to the urethra within the penis.

- This tube plays a crucial role in the male reproductive system by serving as the main conduit for sperm transport.

- During ejaculation, the vas deferens contracts rhythmically to propel mature sperm from the epididymis through the tube toward the urethra. This process ensures that sperm are delivered efficiently and effectively in preparation for potential fertilization. Additionally, the vas deferens passes through the spermatic cord and the inguinal canal, which are important anatomical structures that support and protect it.

The vas deferens also temporarily stores sperm and contributes to the mixing of sperm with seminal fluid from accessory glands, forming semen that is ultimately expelled during ejaculation.



3.D. Ejaculatory Duct

•The ejaculatory duct is a paired structure, essential for the transport of sperm during ejaculation.

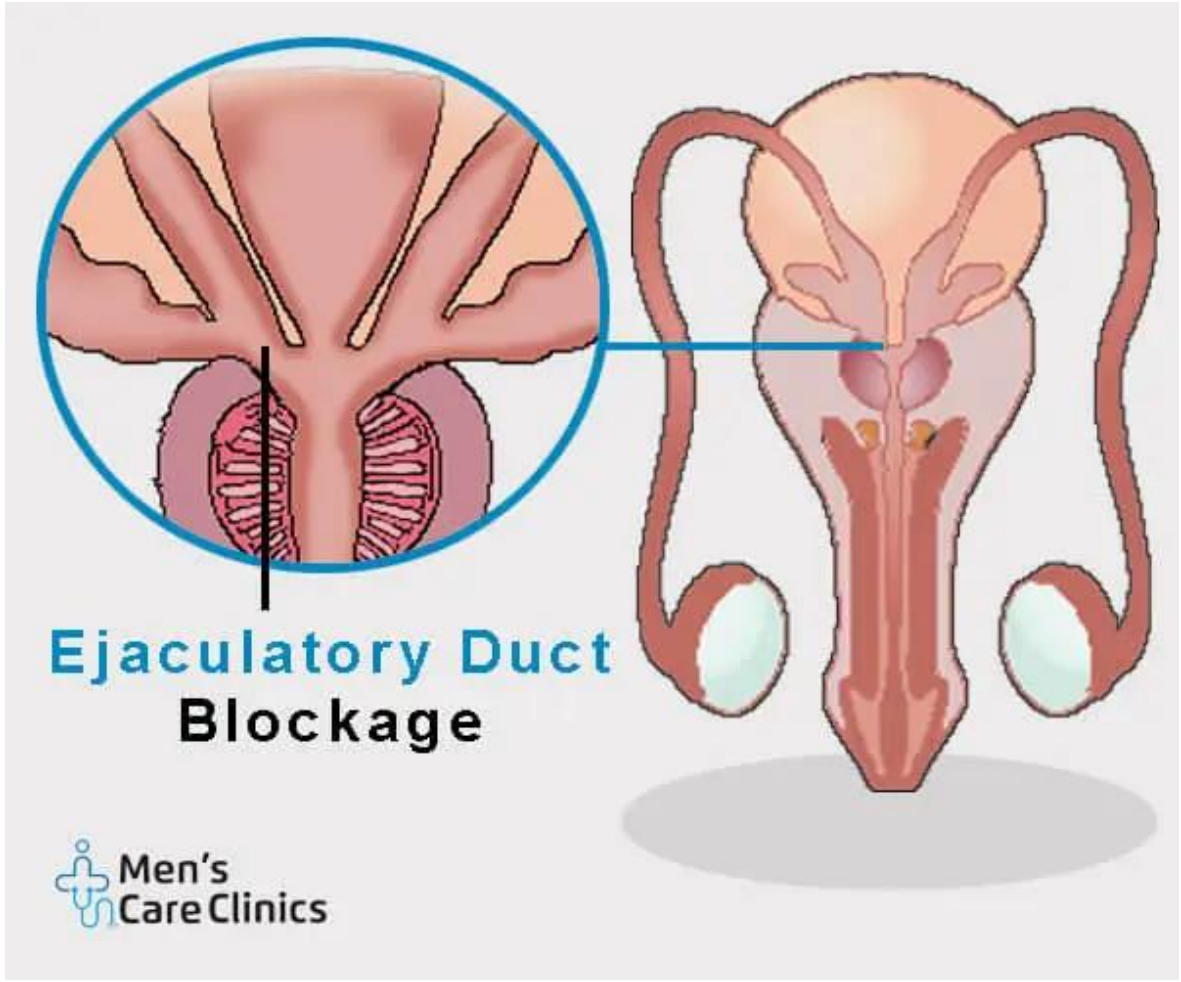
•Each ejaculatory duct is formed by the union of the vas deferens and the duct of the seminal vesicles, combining sperm with seminal fluid.

•These ducts travel through the prostate gland, where they open into the prostatic urethra, allowing the mixture of sperm and seminal fluid to enter the urethra.

•Functionally, the ejaculatory ducts serve as conduits that ensure the proper delivery of sperm and seminal fluid during ejaculation, contributing to male fertility.

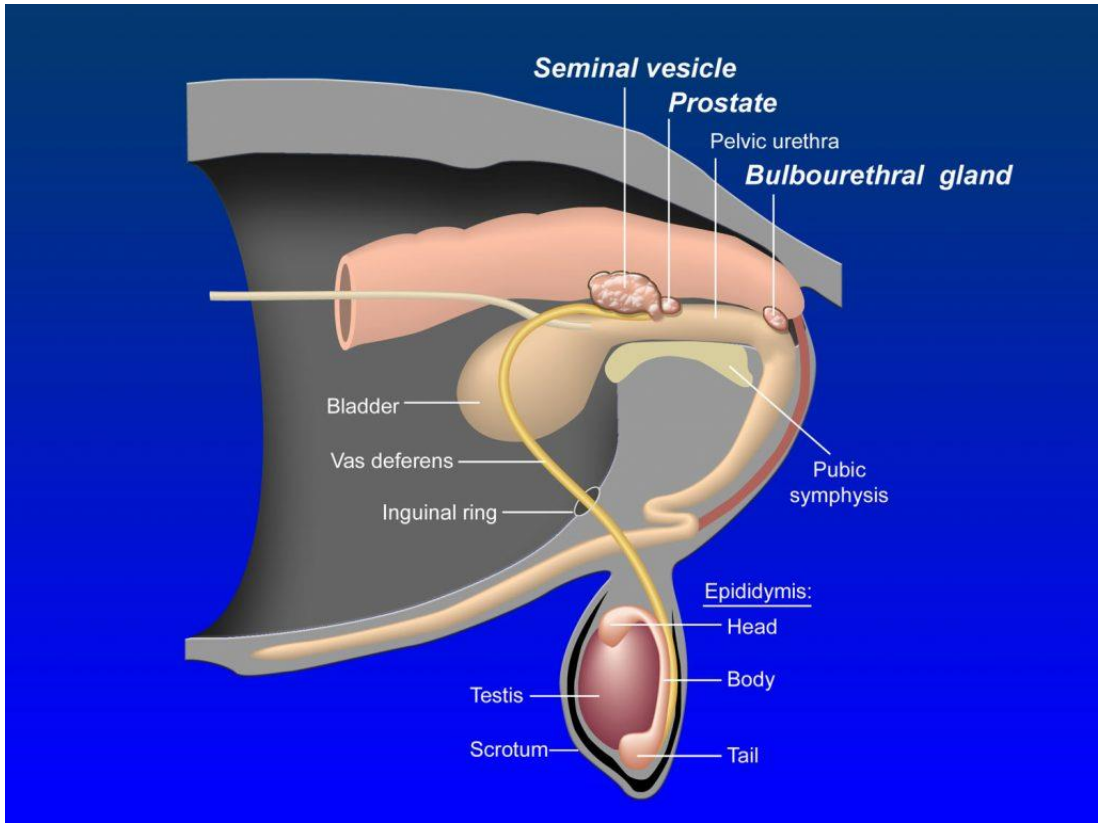
•The passage through the prostate also allows for the addition of prostatic secretions, which help nourish and protect sperm.

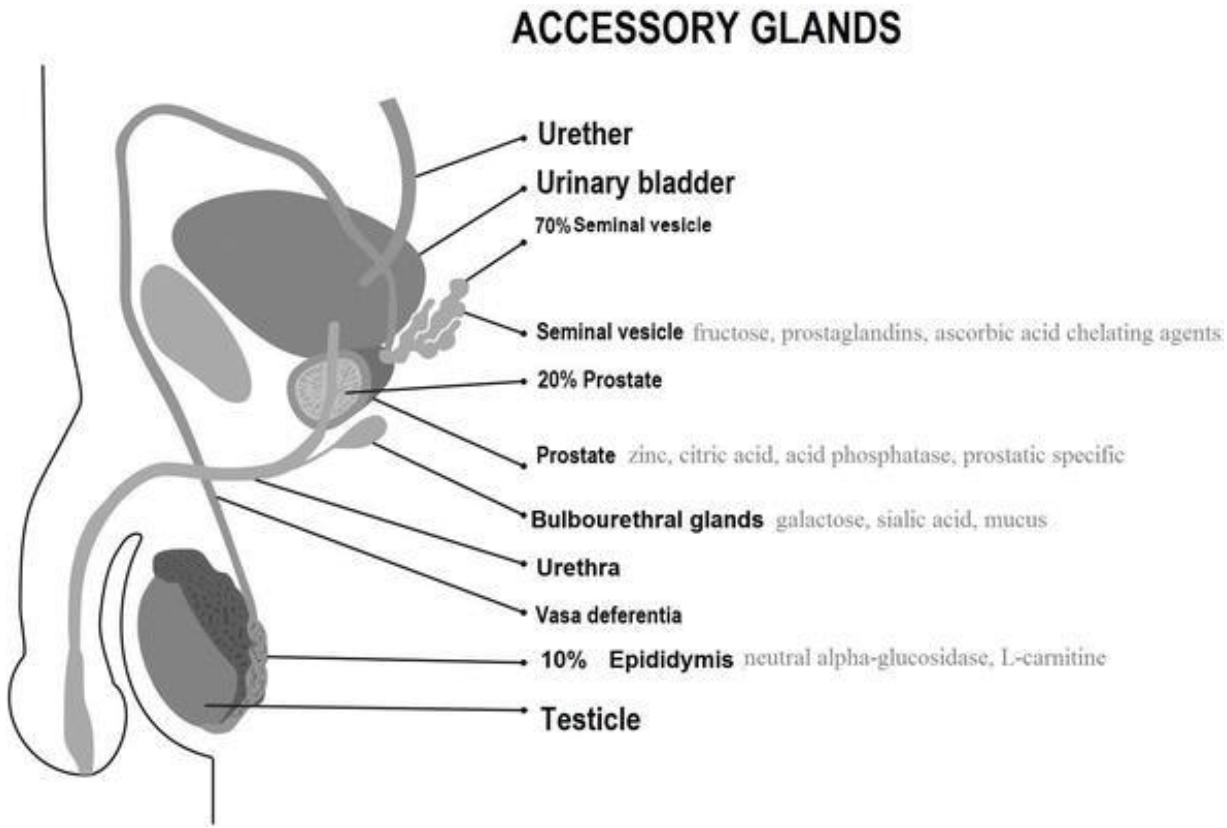
•Any obstruction or dysfunction in the ejaculatory ducts can lead to issues such as infertility or painful ejaculation, highlighting their clinical importance.



3.E. Accessory glands

1. Seminal Vesicles
2. Prostate Gland
3. Bulbourethral Glands





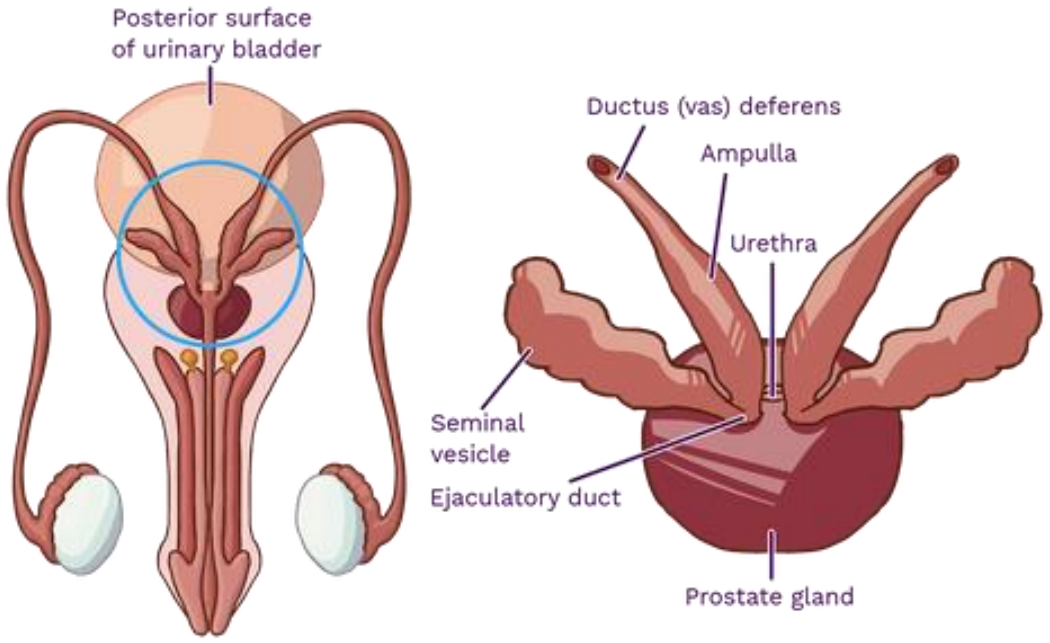
These glands produce nourishing fluids for the sperms that enter the urethra

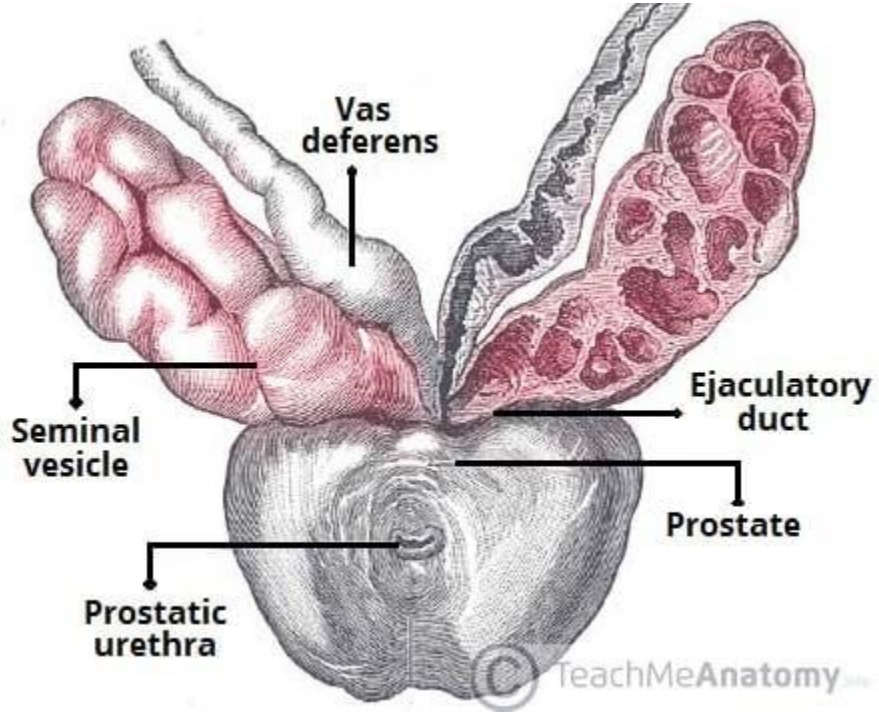
3.E. Accessory glands

1. Seminal Vesicles

- The seminal vesicles are a **pair of sac-like glands** located behind the bladder and attached to the vas deferens, which is the duct that transports sperm from the testes. These glands play a crucial role in male reproductive health by **producing a thick, sticky, yellowish fluid that is rich in fructose (60%), a type of sugar**.

- This fluid serves several important functions: it provides an energy source for sperm cells, helping them to remain motile and viable as they travel through the female reproductive tract. Additionally, the seminal vesicle fluid contributes to the volume of semen, facilitating sperm transport during ejaculation. The fructose content is vital because sperm rely on it as a primary energy substrate to sustain their activity and fertilization capability.





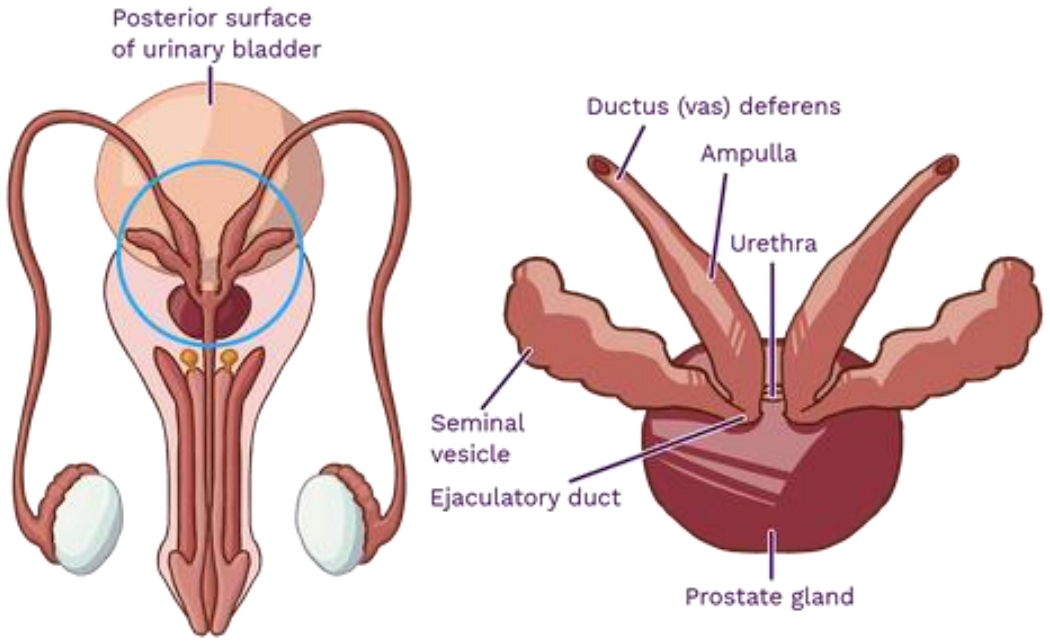
3.E. Accessory glands

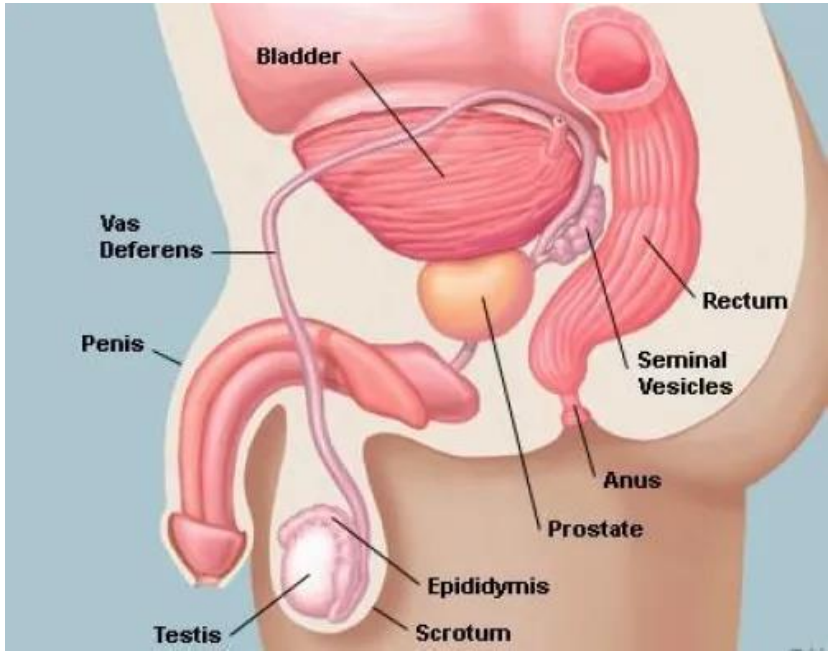
2. Prostate Gland

- **Anatomical Location:** small, walnut-sized organ that surrounds the ejaculatory ducts at the base of the urethra, positioned just below the bladder. This strategic location allows it to play a crucial role in the male reproductive system.

- **Function in Semen Production:** The primary function of the prostate gland is to produce and secrete prostate fluid, which is a key component of semen. The prostate fluid contains 30% of PSA, citrate (pH stabilization), and zinc (chromatin stabilization).

- **Semen** is a complex liquid mixture that contains sperm cells, prostate fluid, and seminal fluid from the seminal vesicles. The prostate fluid contributes to the nourishment and protection of sperm, enhancing their motility and longevity.





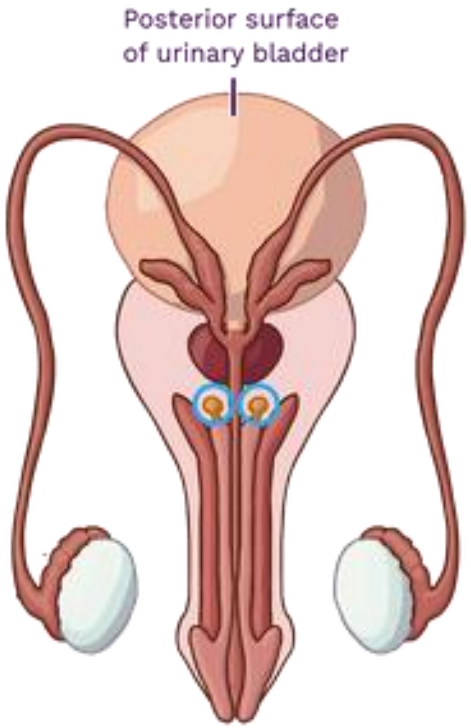
3.E. Accessory glands

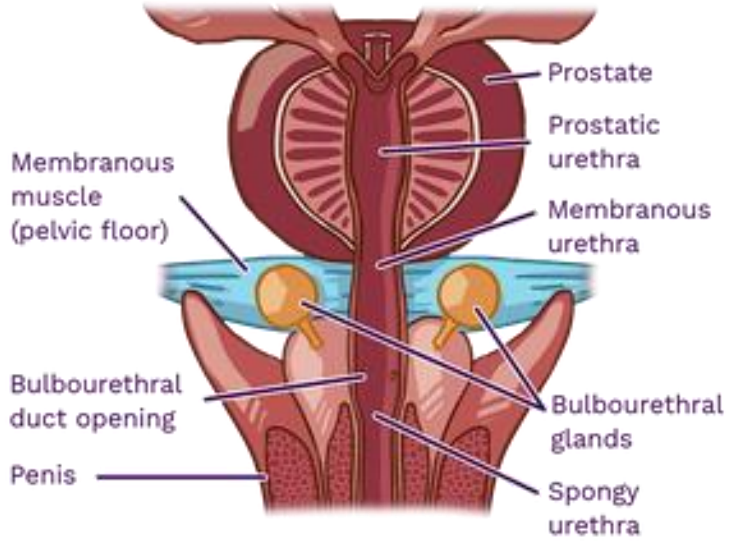
3. Bulbourethral glands (Cowper's gland)

- **Anatomical Location:** The Bulbourethral Glands, also known as Cowper's glands, are two small, pea-sized structures situated on either side of the urethra. They are located just below the prostate gland within the male reproductive system.

- **Function and Secretion:** These glands play a crucial role in male reproductive physiology by producing a clear, slippery fluid. This fluid is secreted directly into the urethra during sexual arousal.

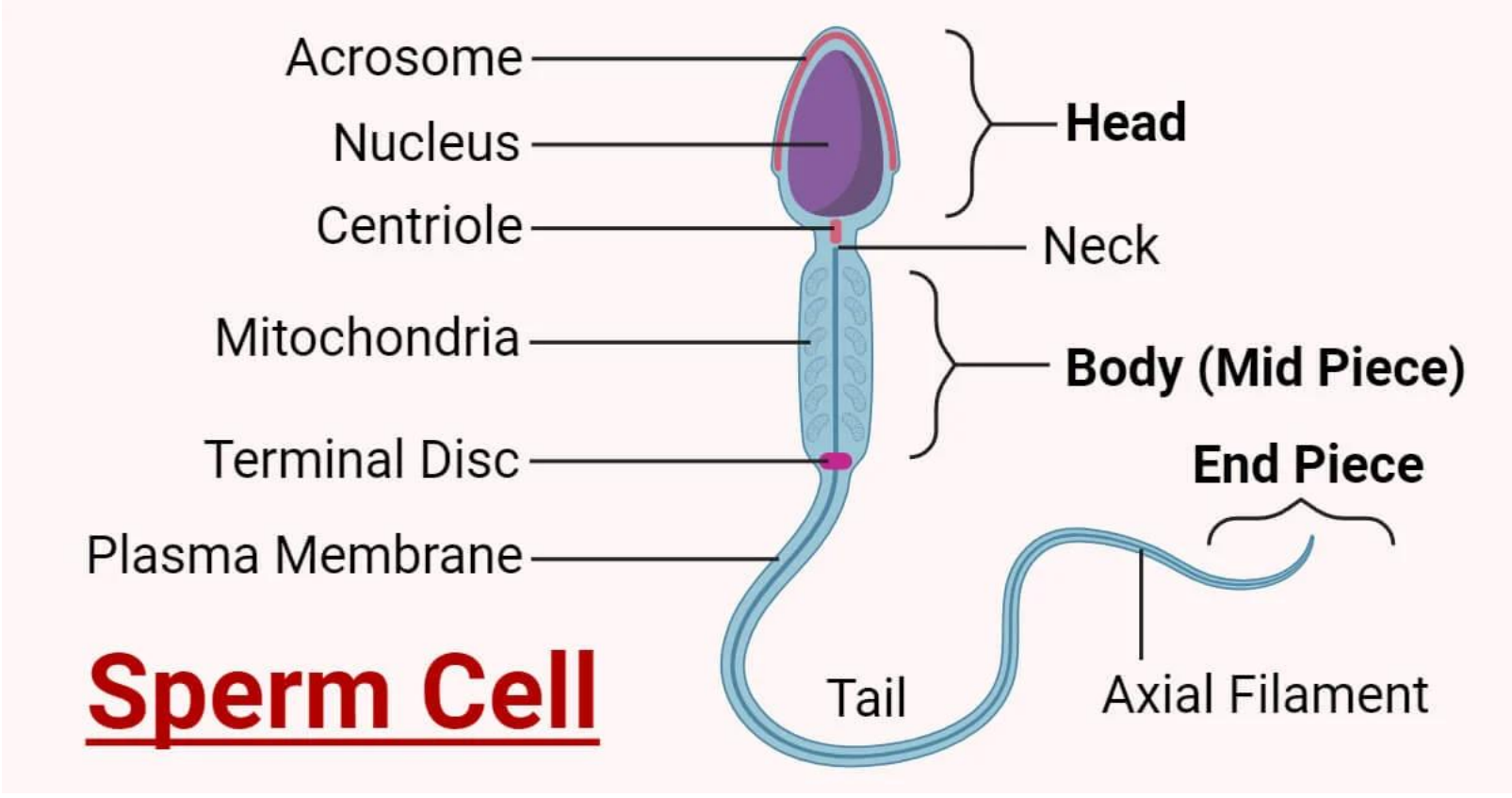
- **Purpose of the Fluid:** it lubricates the urethra to facilitate the smooth passage of sperm during ejaculation, neutralizes traces of acidic urine in the urethra to protect sperm, and helps to reduce friction during intercourse.





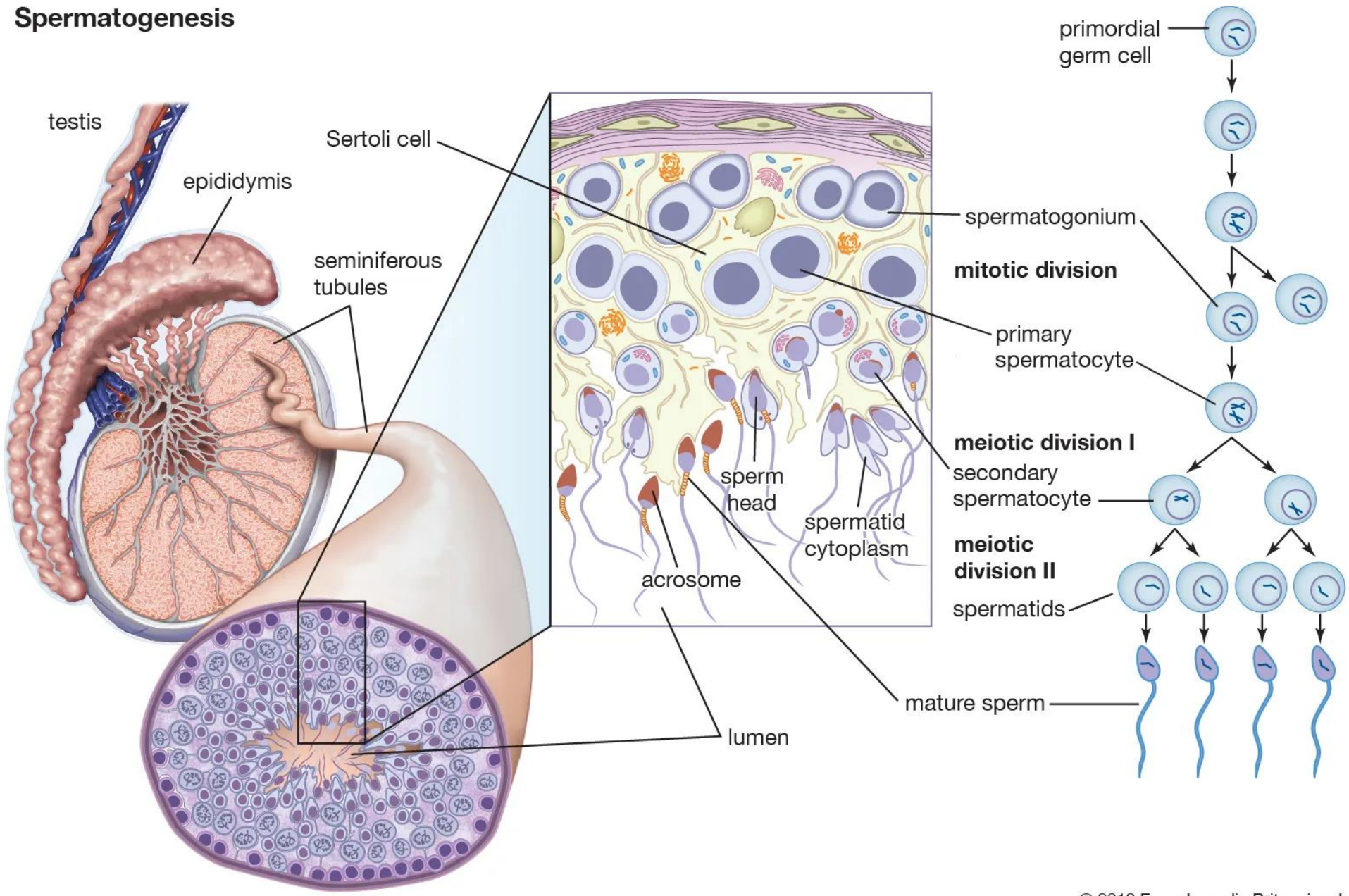
4. Sperm

- **Function:**
  - Designed to transport and deliver genetic material to the female egg (ovum).
- **Structure:**
  - **Head:** The largest sperm region containing the sperm's DNA.
  - **Midpiece:** The narrow middle part of the cell that contains mitochondria, providing the energy needed for movement.
  - **Tail:** The wavelike motion of the flagellum popels the sperm forward through fluid environments.



4. A. Spermatogenesis

- Spermatogenesis is the formation of sperm cells.
- It takes place in the seminiferous tubules.
- Duration about 74 days.



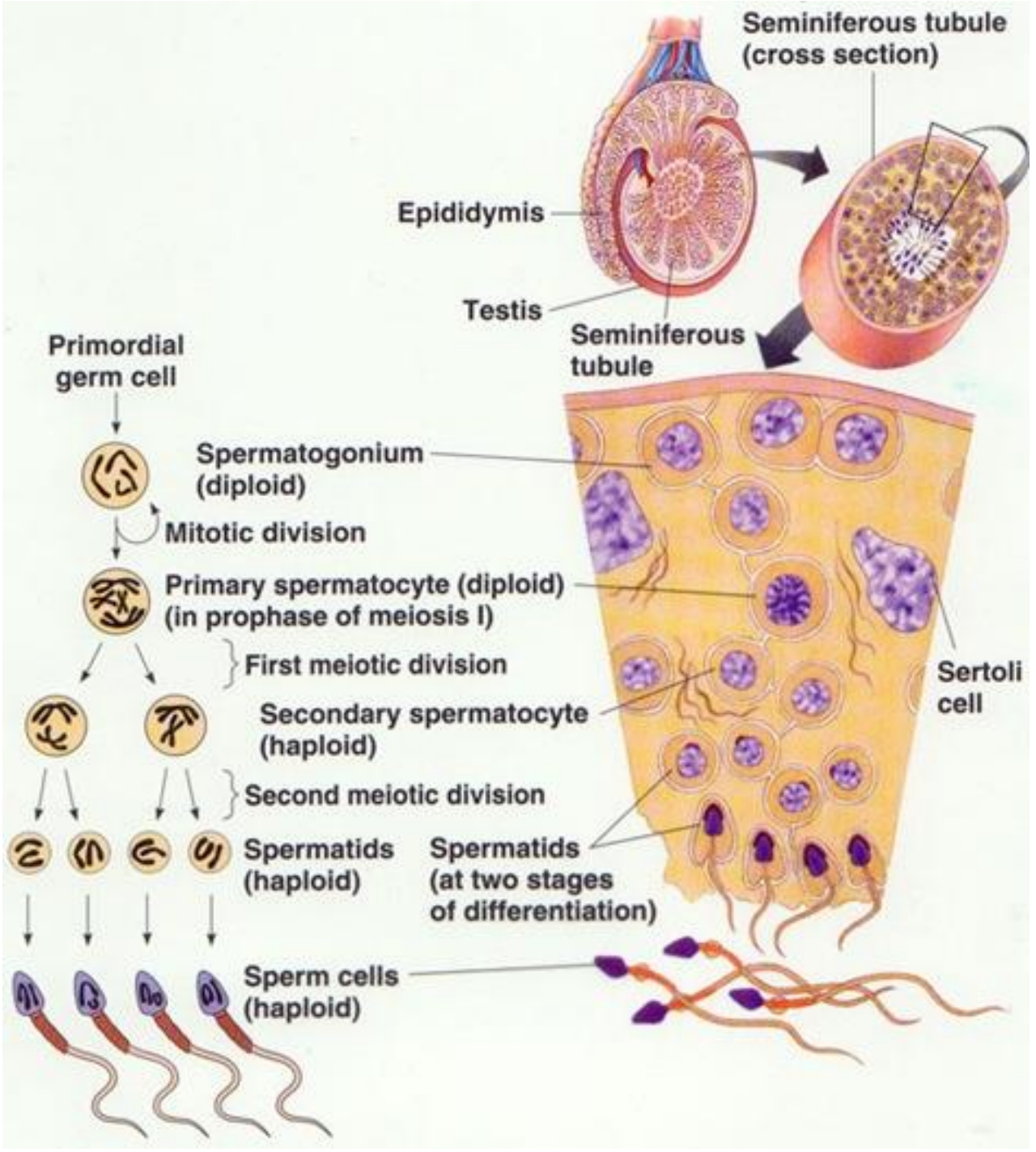
4. A. Spermatogenesis

- Spermatogenesis is the process where male reproductive cells develop into mature sperm. This happens inside tiny tubes in the testes and is important for making sure men can have children.

The process has three main steps:

1.Spermatogonial Phase (Mitotic Division): This initial phase involves the proliferation of spermatogonia, which are the diploid stem cells. These cells undergo mitotic divisions to maintain the stem cell population and produce primary spermatocytes (around 3 million daily).

2.Meiotic Phase: Primary spermatocytes enter meiosis I to form secondary spermatocytes, which then quickly proceed through meiosis II to produce haploid spermatids (n=23). This reduction in chromosome number is crucial for maintaining genetic stability upon fertilization.



3.Spermiogenesis: This final phase involves the transformation of round spermatids into elongated, motile spermatozoa. During spermiogenesis, spermatids develop a flagellum for motility, condense their nuclear material, and form the acrosome, which is vital for penetrating the egg during fertilization.

Throughout spermatogenesis, **Sertoli cells** provide structural and nutritional support, creating a nurturing environment for developing sperm cells.

Hormonal regulation, primarily by **follicle-stimulating hormone (FSH) and testosterone**, orchestrates the timing and progression of this process.